REVISED DRAFT

APPENDICES TO
AN ASSESSMENT OF U.S. COMPETITIVENESS IN
HIGH TECHNOLOGY INDUSTRIES

September 8, 1982

APPENDIX A

DEFINING TECHNOLOGY-INTENSIVE TRADE

OVERVIEW

The technology-intensive component of trade has been an extremely difficult concept to measure quantitatively. Nevertheless, three techniques have been developed to define technology intensive trade, all of which have contributed to the analysis of the U.S. competitive situation. This report has attempted to avoid entering a debate concerning the best identification technique, while remaining aware of the problems associated with each. The purpose of the report is to assess the competitive situation of both products and industries which have been shown as technology intensive by all methods. In addition, since the report takes both a product and an industry perspective it was necessary to use several of the identification methods to acquire a complete picture of the competitive situation. Finally, as the data in the statistical appendix illustrate, the general trend of declining U.S. competitiveness is shown to exist using any of the definitions of technology intensity.

No single definition of high technology trade has been shown to be the best or most definitive for several reasons. The question of what can be considered the best proxy for technology intensity has yet to be resolved: R&D expenditures, and scientists and engineers in the workforce are only proxies for technology intensity. Additionally, even at their most disaggregated level, product data frequently contain both technology-intensive and non-technology intensive goods. The very nature of technological change, also, precludes a final definition of specific goods or industries as high technology, as the situation is constantly changing.

The definition of what constitutes technology-intensive trade has been a subject of controversy since the mid 1970s. The search for an appropriate U.S. policy concerning international technology transactions, which has continued since the late 1960s, served as the impetus for several studies concerning the effects of technology on trade. These studies have developed three techniques for identifying technology intensive activities and have been the source of debate concerning which method presents the best measure of technology intensive trade. Two have identified technology-intensive trade on a product basis and one has identified it on an industry basis.

It should be noted that the R&D data available requires that industries or products must be considered at a fairly aggregated level. Consequently, some specific sub-industries which are really of a fairly low technology intensity are included in the definition. Also, some specific high technology industries are excluded. Detailed industry examinations -- such as those discussed in Appendix C -- should, though, consider specific high technology industries (for instance, robotics and computer-related machine tools) which are excluded from the aggregate definitions made for trade data purposes.

INDUSTRY BASED DEFINITION

M. Boretsky (1974, 1982) developed an industry-based definition (DOC1) of technology-intensive trade. Boretsky used industry R&D expenditures as a percentage of industry value added, and industry employment of scientists, engineers and technicians as a proportion of the industry workforce to determine which industries were technology-intensive and a sub-group which were considered high technology. Since he used an industry basis, the definition did not differentiate between the technology-intensive and non-technology intensive products within each industrial sector. Industries generally produce a wide range of products which will fall in both the technology-intensive and the non-technology intensive categories. In spite of this, the Boretsky definition has been useful in identifying which industries can be considered to be high technology industries.

PRODUCT BASED DEFINITIONS

In order to account for the wide range of products produced by any one industry, R. Kelly (1974, 1977) developed an index of technology-intensity on a product rather than industry basis. Kelly used applied R&D expenditures by product field and the value of product shipments to devise intensity ratios. After the products were ranked by their "intensity," they were then divided into technology classifications. Kelly, somewhat arbitrarily, selected the first quartile of R&D intensities as high technology goods (1974), but later defined product groups with above average R&D intensities (DOC2) as technology intensive.

Aho and Rosen (1980) essentially used Kelly's technique to determine which product groups were technology-intensive. They used more recent R&D expenditures data and shipments data on a product line basis to develop an intensity index. After ranking the product groups by intensity, they also identified product groups with above average intensities as high technology products. In order to facilitate international comparisons, Aho and Rosen concorded the U.S. data with trade data classified according to the Standard International Trade Classification (SITC). The concordance was a particularly useful contribution as foreign data has been available on a SITC basis only (the Kelly definition has also been concorded to SITC).

In a recent study, L. Davis (1982) developed a technique using input-output (I-O) analysis, and R&D expenditure and shipments data by product group to calculate a technology-intensity index. Based on the belief that the total R&D embodied in a product group presented a more accurate measure of technology intensity, Davis used an I-O matrix to determine the value of R&D embodied in the products (inputs) used to produce the product in question, and the percentage of that value which was contained in the final product. The value of the indirect R&D (R&D contributed by inputs) was then combined with the value of the direct R&D (R&D expenditures directly on the product development) to find total R&D. Davis next ranked product groups according to their total R&D to shipments intensity.

He then made another break with tradition by designating goods as high technology products (DOC3) only when they showed a significantly greater R&D intensity, rather than simply an above average R&D intensity.

Two consumer product groups, automobiles and radio and television receivers, were excluded from the high technology products in the analysis of international trade performance in this report. Though including these two product groups would have revealed an even larger deterioration of the U.S. position, the evidence supporting their inclusion is ambiguous. Neither the DOC2 nor the DOC3 definitions identified automobiles as technology intensive and recent, more disaggregated R&D expenditures data show radio and television receivers to be below average in technology intensity.

REFERENCES

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DOCI DEFINITION OF HIGH TECHNOLOGY INDUSTRIES

High-Technology Industries[1]

Description	SIC[2] Number
(1) Drugs and medicinals	283
(2) Office, computing, and accounting equipment	357
(3) Radio, television, and communications equipment, and electronic components:	
Radio- and TV-receiving equipment, except communications types	365
Communications equipment	366
Electronic components and accessories	367
(4) Electrical apparatus and equipment: (excludes categories 365, 366 and 367)	36
(5) Aerospace and missiles:	
Aircraft and parts	372
Guided missiles and spacecraft	376
(6) Instruments and related products	38

TECHNOLOGY-INTENSIVE INDUSTRIES[3]

Description	SIC Number
(1) Chemicals and related products	28
(2) Nonelectrical machinery	35
(3) Electrical and electronic equipment	36
(4) Transportation equipment, missiles, and ordnance	37
(5) Instruments and related products	38

1 As a general proposition technology-intensive industries are defined as those industries which normally spend 5 percent or more of their gross product (BEA concept of value added) on R&D and/or normally 5 percent or more of their total employment consists of "natural" scientists, engineers and technicians. High-technology industries normally spend at least 10 percent of their gross product (value added) on R&D and/or at least 10 percent of their total employment consists of "natural scientists, engineers and technicians."

2 Standard Industrial Classification.

3 Includes industries classified as high technology.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Economic and National Security Implications," Draft, International Trade Administration, U.S. Department of Commerce, March 1982.

DOC2 DEFINITION OF HIGH TECHNOLOGY PRODUCTS

Description	SITC[1] Number
(1) Aircraft and parts (SIC 372):	
Aircraft engines includes: internal combustion engines, and jet and gas turbines for aircraft	711.4
Aircraft includes: Aircraft, heavier-than-air; airships and balloons; and parts of aircraft, airships and balloons	734
(2) Office, computing, and accounting machines (SIC 357):	
Office machines includes: typewriters and check writing machines; calculating, accounting and similar machines (includes electronic computers); statistical machines; and office machines and parts not specified elsewhere	714
Weighing machinery and weights therefor	719.63
(3) Electrical transmission and distribution equipment (SIC 361, 362, 366 & 367):	
Electrical power machinery and switchgear	722
Telecommunications equipment: not elsewhere specified, includes: electrical line and telegraph equipment; microphones, loudspeakers and amplifiers; and other telecommunications equipment	724.9
Thermionic, etc., valves and tubes, photocells, transitors	729.3
Electron and proton accelerators	729.7
Phonograph records, recorded tapes, and other recorded media	891.2
(4) Optical and medical instruments (SIC 383-387):	
Pharmaceutical goods	541.9
Photographic and optical goods, watches and clocks	86 (excluding 861.8 and 861.9)
(5) Drugs and medicines (SIC 283):	
Medicinal and pharmaceutical products (Does not include 541.9)	541

Description	SITC Number
(6) Plastic materials and synthetics (SIC 282):	
Plastic materials, regenerated cellulose, and resins	581
Yarn and thread of synthetic fibers	651.6
(7) Engines and turbines (SIC 351):	
Steam engines	711.3
Internal combustion engines (other than for aircraft)	711.5
Gas turbines (other than for aircraft)	711.6
Engines not specified elsewhere	711.8
(8) Agricultural chemicals (SIC 287):	
Manufactured fertilizers	561
Insecticides, fungicides, disinfectants and similar preparations	599.2
(9) Professional, scientific, and measuring instruments (SIC 381 & 382):	
Electrical measuring and controlling instruments and apparatus	729.5
Meters and counters, nonelectric	861.8
Measuring, controlling, and scientific instruments, not specified elsewhere	861.9
(10) Industrial chemicals (SIC 281):	
Chemical compounds and elements	51
Synthetic organic dyestuffs, natural indigo and color lakes	531
Synthetic tanning materials	432.3
Coloring materials not specified elsewhere	533.1
Essential oils and resinoids	551.1
(11) Radio and TV receiving equipment (SIC 365):	
Television broadcast receivers	724.1
Radio broadcast receivers	724.2
Phonographs, tape recorders and other sound recorders and reproducers	891.1

[1] Standard International Trade Classification, Revision 1.

NOTE: Kelly did not include the portion of guided missiles and spacecraft found in ordnance and accessories in the definition of high technology products, as these products are not included in the U.N. classification of manufactured products (SITC 5-8). Aircraft and parts (SITC 734) do include products related to spacecraft.

SOURCES: Kelly, R.K., "The Impact of Technological Innovation on International Trade Patterns," Office of International Economic Research, U.S. Department of Commerce, December 1977.

United Nations, "Standard International Trade Classification Revised," Statistical Papers Series M No. 34, 1961.

DOC3 DEFINITION OF HIGH TECHNOLOGY PRODUCTS

	Description	SIC[1] Number
(1)	Guided missiles and spacecraft	376
(2)	Communications equipment and electronic components:	
	Radio- and TV-receiving equipment, except communications types	365
	Communications equipment	366
	Electronic components and accessories	367
(3)	Aircraft and parts	372
(4)	Office, computing, and accounting machines	357
(5)	Ordnance and accessories, except vehicles and guided missiles	348
(6)	Drugs and medicines	283
(7)	Industrial inorganic chemicals	281
(8)	Professional and scientific instruments (excludes category 3825)	38
(9)	Engines and turbines	351
(10)	Plastic materials and synthetic resins, synthetic rubber and other man-made fibers, except glass	282

[1] Standard Industrial Classification.

SOURCES: Davis, L.A., "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, U.S. Department of Commerce, February 1982.

<u>Standard Industrial Classification Manual, 1972</u>, Office of Management and Budget, 1972.

APPENDIX B

STATISTICAL TABLES

Table 1

SOME BASIC INDICATORS, 1978

	United States	Japan	West Germany	France
Population (millions)	218.5	114.9	61.3	53.2
Annual Growth*	0.8 %	1.2 %	0.1 %	0.6 %
Labor Force (millions)	102.5	55.3	25.2	22.4 [1]
Annual Growth*	2.2 %	0.9 %	-0.7 %	0.7 %
GNP Per Capita (U.S. Dollars)	$9,770	$7,700	$10,300	$8,880
Annual Real*	2.3 %	7.8 %	2.4 %	3.1 %
Higher Education (as % of Age Group)	41.0 %	24.7 %	13.6 %	18.8 %

[1] 1977

* Since 1970

SOURCES: 1980 World Bank Atlas
Organization for Economic Cooperation and Development (OECD) educational statistics

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Table 2

U.S. AND JAPANESE MERCHANDISE TRADE WITH THE WORLD
(In billions of U.S. dollars)

YEAR	UNITED STATES[1] EXPORTS	IMPORTS	BALANCE	JAPAN[2] EXPORTS	IMPORTS	BALANCE
1960	19.7	15.1	4.6	4.1	4.5	-0.4
1967	31.0	26.9	4.1	10.4	11.7	-1.3
1968	34.1	33.2	0.8	13.0	13.0	-
1969	37.3	36.0	1.3	16.0	15.0	1.0
1970	42.7	40.0	2.7	19.3	18.9	0.4
1971	43.5	45.6	-2.0	24.0	19.7	4.3
1972	49.2	55.6	-6.4	28.6	23.5	5.1
1973	70.8	69.5	1.3	36.9	38.2	-1.3
1974	97.9	100.3	-2.3	55.6	62.0	-6.4
1975	107.7	98.5	9.1	55.8	57.9	-2.1
1976	115.2	123.5	-8.3	67.2	64.8	2.4
1977	121.2	160.5	-39.4	80.5	70.8	9.7
1978	143.7	186.0	-42.4	97.5	79.3	18.2
1979	181.9	222.3	-40.4	103.0	110.7	-7.7
1980	220.6	257.0	-36.4	129.8	140.5	-10.7

1 U.S. imports are on a cost of merchandise basis (fas) prior to 1977. From 1977 through 1980, U.S. imports are on a cost of merchandise, insurance and freight basis (cif).

2 Japan's exports are on a customs value basis, imports are cif.

SOURCE: "International Economic Indicators," International Trade Administration, Department of Commerce, Various issues.

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Table 3

WEST GERMAN AND FRENCH MERCHANDISE TRADE WITH THE WORLD
(In billions of U.S. dollars)

	WEST GERMANY[1]			FRANCE[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	11.4	10.2	1.2	7.2	5.9	1.3
1967	21.8	17.5	4.3	11.4	11.6	-0.2
1968	24.9	20.3	4.6	12.9	13.0	-0.1
1969	29.1	25.1	4.0	15.4	16.5	-1.1
1970	34.2	29.9	4.3	18.1	17.9	0.2
1971	39.1	34.5	4.6	20.7	19.8	0.9
1972	46.2	39.9	6.3	26.4	25.3	1.1
1973	67.5	54.8	12.7	36.6	35.3	1.3
1974	89.3	69.6	19.7	46.6	49.9	-3.3
1975	90.2	74.9	15.3	53.0	51.4	1.6
1976	102.2	88.4	13.8	57.0	61.4	-4.4
1977	118.1	101.5	16.6	65.0	70.5	-5.5
1978	142.5	121.8	20.7	79.1	81.6	-2.5
1979	171.6	159.3	12.3	100.6	107.5	-6.9
1980	192.9	188.0	4.9	116.1	135.0	-18.9

1 West German imports are on a cif basis.

2 French imports are on a cost of merchandise and loading for shipment (fob) basis before 1977 and on a cif basis from 1977 through 1980.

SOURCE: "International Economic Indicators," International Trade Administration, U.S. Department of Commerce, Various issues.

Table 4

U.S. AND JAPANESE MANUFACTURED PRODUCTS TRADE
WITH THE WORLD
(In billions of U.S. dollars)

	UNITED STATES[1]			JAPAN[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	12.7	6.8	5.9	3.6	1.0	2.6
1967	21.1	15.8	5.3	9.8	3.1	6.7
1968	24.1	20.6	3.5	12.2	3.5	8.7
1969	27.1	23.0	4.1	15.0	4.4	10.6
1970	29.7	25.9	3.4	18.1	5.6	12.5
1971	30.8	30.4	0.4	22.6	5.5	17.1
1972	34.3	37.8	-3.5	27.1	6.8	20.3
1973	45.6	45.0	0.6	34.8	11.5	23.3
1974	64.6	55.2	9.3	52.5	14.5	38.0
1975	71.0	51.1	19.9	53.2	11.5	41.7
1976	77.2	64.8	12.5	64.6	13.4	51.2
1977	80.2	81.9	-1.8	77.7	14.7	63.0
1978	94.5	106.8	-12.3	94.2	20.0	74.2
1979	116.6	118.8	-2.1	99.1	27.1	72.0
1980	143.9	131.5	12.5	124.4	30.7	93.7

1 U.S. imports are on a fas basis prior to 1977 and on a cif basis from 1977 through 1980.

2 Japan's imports are on a cif basis for all years.

SOURCE: "International Economic Indicators," International Trade Administration, U.S. Department of Commerce, Various issues.

Table 5

WEST GERMAN AND FRENCH MANUFACTURED PRODUCTS TRADE
WITH THE WORLD
(In billions of U.S. dollars)

	WEST GERMANY[1]			FRANCE[2]		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1960	10.1	4.2	5.9	5.1	2.4	2.7
1967	19.5	8.5	11.0	8.4	7.0	1.4
1968	22.3	10.6	11.7	9.4	8.4	1.0
1969	26.2	13.9	12.3	11.0	10.9	0.1
1970	30.7	17.4	13.3	13.5	12.0	1.5
1971	35.0	20.0	15.0	15.1	13.3	1.8
1972	41.5	23.8	17.7	19.1	15.7	3.4
1973	60.3	31.6	28.7	26.1	23.8	2.3
1974	78.9	36.5	42.4	33.2	30.2	3.0
1975	79.6	50.0	29.6	39.6	30.7	8.9
1976	90.7	48.6	42.1	42.5	37.6	4.9
1977	104.3	57.4	46.9	48.7	40.7	8.0
1978	125.2	71.7	53.3	58.8	49.2	9.6
1979	150.6	91.4	59.2	75.6	64.1	11.5
1980	166.9	103.8	63.1	84.0	76.6	7.4

1 West German imports are on a cif basis.

2 French imports are on a cost of merchandise and loading for shipment (fob) basis before 1977 and on a cif basis from 1977 through 1980.

SOURCE: "International Economic Indicators," International Trade Administration, U.S. Department of Commerce, Various issues.

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Table 6

CLASSIFICATION OF U.S. MANUFACTURING INDUSTRIES IN ACCORDANCE WITH THEIR TECHNOLOGICAL INTENSITY

Industry Groupings	Criteria of Intensity					
	1. Expenditures on R&D as Percent of Gross Product Originated (BEA Concept of Value Added), %			2. Employment of Scientists, Engineers and Technicians Working with R&D and All Other Functions as Percent of Total Employment %		
	1961	1970	1980	1961	1970	1980
A. All Manufacturing Industries	7.4	6.9	7.2	5.4	5.9	6.1
B. Technology-Intensive Industries:[1]						
o Chemicals and Related Products (SIC 28)	10.1	9.7	10.0	13.9	14.7	13.1
o Nonelectrical Machinery (SIC 35)	6.9	6.3	8.2	8.5	8.7	10.6
o Electrical and Electronic Equipment (SIC 36)	20.8	19.2	15.8	14.3	14.3	13.3
o Transportation Equipment Missiles and Ordnance (SIC 37)	26.4	22.6	22.9	10.7	12.1	11.0
o Instruments and Related Products (SIC 38)	8.3	10.9	13.3	13.6	13.2	13.3
Technology-Intensive, Average	16.9	14.8	14.2	11.7	12.2	11.9
B1. High Technology Industries:[1]						
- Drugs and Medicinals (SIC 283)	11.2	16.9	22.1	17.8	16.8	18.1
- Office, Computing and Accounting equipment (SIC 357)	28.5	36.2	33.2	NA	19.5	15.6
- Radio, Television, Communications Equipment and Electronic Components (SIC 365, 366, and 367)	24.2	23.7	16.4	18.7	18.1	18.5
- Electrical Apparatus and equipment (SIC 36 Minus SIC 365, 366, and 367)	17.6	14.5	14.7	9.7	10.2	6.3
- Aerospace and Missiles (SIC 372 and 376)	50.7	39.6	45.9	11.1	19.3	15.6
- Instruments and Related Products (SIC 38)	8.3	10.9	13.3	13.6	13.2	13.3
High Technology, Average	27.6	24.6	23.2	13.3[2]	16.0	15.5

Table 6 (cont'd.)

CLASSIFICATION OF U.S. MANUFACTURING INDUSTRIES IN ACCORDANCE WITH THEIR TECHNOLOGICAL INTENSITY--Cont.

Industry Groupings	Criteria of Intensity: 1. Expenditures on R&D as Percent of Gross Product Originated (BEA Concept of Value Added), %			2. Employment of Scientists, Engineers and Technicians Working with R&D and All Other Functions as Percent of Total Employment %		
	1961	1970	1980	1961	1970	1980
B2. Technology-Intensive Other Than the High-Technology industries:						
-- Chemicals Except Drugs and Medicinals (SIC 28 Minus SIC 283)	10.0	8.3	7.6	13.3	14.3	12.0
-- Nonelectrical Machinery Except Office, Computer and Accounting Equipment (SIC 35 Minus SIC 357)	4.5	2.3	2.9	NA	6.9	6.9
-- Motor Vehicles and Equipment (SIC 371)	9.9	10.4	15.9[3]	4.5	6.3	3.6
-- Transportation Equipment Other Than Motor Vehicles, Aircraft and Missiles (SIC 37 Minus SIC 371, 372 and 376)	3.1	2.1	1.2	27.8	4.1	17.0
B2. Average	7.8	6.2	6.8	11.6[4]	8.3	8.3
C. Not Technology-Intensive Industries,[5] Average	1.3	1.4	1.7	2.0	2.0	2.1

Sources: Bureau of Economic Analysis (BEA), Bureau of the Census, Bureau of Labor Statistics and National Science Foundation.

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Footnotes for Table 6

[1] As a general proposition technology-intensive industries are defined as those industries which normally spend 5 percent or more of their gross product (BEA concept of value added) on R&D and/or normally 5 percent or more of their total employment consists of "natural" scientists, engineers and technicians. High-technology industries normally spend at least 10 percent of their gross product (value added) on R&D and/or at least 10 percent of their total employment consists of "natural" scientists, engineers and technicians.

[2] Net of the office, computing, and accounting equipment industry (SIC 357).

[3] Evidently inflated due to the recession of 1980. In 1979 the proportion was 11.7 percent.

[4] Net of nonelectrical machinery industries other than SIC 357.

[5] Consistent with the definition of technology-intensive, not-technology-intensive industries are industries that spend up to 5 percent of their gross product (value added) on R&D and/or up to 5 percent of their total employees are "natural" scientists, engineers and technicians. In reality, most of the U.S. industries other than those classified as technology-intensive normally spend only between 1 and 2 percent of their gross product on R&D, and only about 2 percent of the persons they employ are scientists, engineers and technicians.

SOURCE: Boretsky, M. "The Threat to U.S. High Technology Industries: Economic and National Security Implications," International Trade Administration, U.S. Department of Commerce, March 1982.

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Table 7

RESEARCH-INTENSITY RATIOS[1], THE DOC2
DEFINITION OF HIGH TECHNOLOGY PRODUCTS

SITC CLASS	DESCRIPTION	RESEARCH INTENSITY RATIO (PERCENT)
711.4, 734	Aircraft and Parts	12.41
714, 719.63	Office, computing and accounting machines	11.61
722, 724.9, 729.3, 729.7, 891.2	Electronic transmission and distribution equipment; electrical industrial apparatus; communication equipment and electronic components	11.01
541.9, 86 (excluding 861.8, 861.9)	Optical and medical instruments, photos, and watches	9.44
541 (excluding 541.9)	Drugs and medicines	6.94
581, 561.6	Plastic materials and synthetics	5.62
711.3, 711.5, 711.6, 711.8	Engines and Turbines	4.76
561, 599.2	Agricultural chemicals	3.64
729.5, 861.8 861.9	Professional, scientific, and measuring instruments	3.17
51, 531, 532.3, 533.1, 551.2	Industrial chemicals	2.78
724.1, 724.2, 891.1	Radio and TV receiving equipment	2.57
5-8	Total manufacturing	2.36[2]

[1] The ratio of applied R&D funds by product field to shipments by product class.

[2] This is the average intensity of all manufactured products.

SOURCE: Kelly, R.K. "The Impact of Technological Innovation on International Trade Patterns." Office of International Economic Research, U.S. Department of Commerce. December 1977.

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Table 8

U.S. MANUFACTURES RANKED BY TOTAL EMBODIED R&D[1], THE DOC3 DEFINITION OF HIGH TECHNOLOGY PRODUCTS[2]

SIC CLASS	DESCRIPTION	TOTAL INTENSITY[3] (PERCENT)
376	Guided missiles and spacecraft	63.86
365, 366, 367	Communications equipment and electronic components	16.04
372	Aircraft and parts	15.40
357	Office, computing, and accounting machines	13.65
348	Ordnance and accessories	13.64
283	Drugs and medicines	8.37
281	Industrial inorganic chemicals	8.23
38 (excluding 3825)	Professional and scientific instruments	5.70
351	Engines, turbines and parts	5.49
282	Plastic and synthetic materials	5.42
	Weighted average all manufacturers	3.30

[1] The total of direct and indirect R&D expenditures.

[2] High technology products are defined as those having significantly higher R&D embodied in them. Plastic and synthetic materials have 30 percent more R&D embodied in them than agricultural chemicals (the next group of products in the ranking).

[3] Total R&D expenditures, both direct and indirect, as a percentage of product shipments.

SOURCE: Davis, L.A. "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, U.S. Department of Commerce, February 1982.

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Table 9

TRENDS IN U.S. MERCHANDISE TRADE BALANCES OF BASIC
COMMODITY GROUPS, THE DOC1 DEFINITION
SELECTED YEARS 1951-1980
(In Billions of U.S. Dollars)

Item	Average 1951-1955	1960	1966	1971	1976	1980
A. Trade largely dependent on relative endowment in natural resources:						
1. Agricultural products	-1.2	+1.0	+2.3	+1.9	+11.8	+23.8
2. Raw material & energy	-2.0	-1.7	-3.1	-4.1	-30.6	-62.3
A. Total	-3.2	-0.7	-0.8	-2.2	-18.8	-44.5
B. Trade largely dependent on technology and other competitive forces:						
1. Technology-intensive manufactured products[1]	+5.7	+6.6	+8.4	+8.3	+25.7	+42.5
2. Not technology-intensive manufactured products[1]	+1.8	-0.9	-3.6	-8.3	-13.2	-21.5
B. Total (All manufactures)	+7.5	+5.7	+4.8	0.0	+12.7	+21.0
C. Total Merchandise Trade[2]	+4.6	+5.5	+4.8	-1.5	-5.7	-20.1

\+ denotes surplus

\- denotes deficit

[1] For definition see Table 6.

[2] Includes commodities not classified by kind, "special category" commodities and reexport of foreign merchandise.

SOURCE: U.S. Department of Commerce

Table 10

COMPARATIVE TRADE BALANCES (F.O.B) IN DOC[1] TECHNOLOGY-INTENSIVE MANUFACTURED PRODUCTS[1] BY COUNTRY AND AREA

(In Billions of U.S. Dollars)

Area	United States			Japan			West Germany			France		
	1970	1976	1980	1970	1976	1980	1970	1976	1980	1970	1976	1978
World	10.4	26.8	42.4	6.9	35.7	70.9	13.4	40.3	64.6	1.4	6.7	10.0
United States	--	--	--	1.2	7.3	16.4	.9	1.5	2.7	-.7	-1.5	-3.6
Canada	.9	4.2	6.6	.2	.9	1.4	.2	.5	.7	.0	.0	.1
Japan	-1.0	-6.9	-16.3	--	--	--	.2	-.5	-2.2	-.3	-.7	-1.3
Western Europe	2.3	4.6	9.4	.7	5.4	10.7	7.9	21.3	36.6	-.3	-1.0	-.4
West Germany	-.9	-1.7	-3.6	-.1	.6	2.3	--	--	--	-.8	-2.6	-4.0
France	.6	1.0	1.8	-.0	.5	.9	.9	3.0	5.1	--	--	--
United Kingdom	.5	.5	2.3	.1	.6	1.6	.3	1.5	3.2	-.2	-.0	.6
Italy	.2	.2	.6	-.0	.2	.3	.8	2.1	5.3	-.1	-.0	.8
Australia, New Zealand, South Africa	1.0	2.5	4.1	.5	2.2	3.9	.7	1.6	3.1	.2	.5	.7
Eastern Europe	.0	.1	.0	.0	.3	.4	.4	1.8	2.3	.2	.5	.7
USSR	.1	.6	.1	.1	.8	1.1	.2	1.5	2.0	.2	.4	.8
China	--	.1	.7	.2	.6	2.5	.1	.3	.8	.0	.3	.1
OPEC	1.2	8.5	10.9	.4	5.1	10.7	.7	6.3	8.6	.5	3.4	5.7
All Others	6.0	13.3	26.9	3.5	13.3	23.8	2.2	6.0	10.0	1.4	4.5	7.2
NIC's	1.4	3.3	9.1	1.4	5.1	11.6	.4	.8	1.9	.16	.4	.3

[1] Includes SITC Rev. Nos. 5 (Chemicals), 7 (Machinery and Transport Equipment), 86 (Professional and Scientific Instruments), 891 (Sound Recorders, Producers). The industries producing these products spend 5 percent or more of their gross product (BEA concept of value added) on R&D and/or 5 percent or more of their total employees are "natural" scientists, engineers, and technicians.

SOURCE: United Nations

Notes to Table 10

- o The United States is doing all right if considered in isolation. As of 1980, however, U.S. balance was only 60 percent of Japan's and 65 percent of Germany's.

- o The bulk of the U.S. surplus, 63 percent, is derived from trade with "All Other Countries"--largely non-OPEC LDC's, a market requiring continuous and most probably nonrepayable infusion of funds to remain viable. Japan derives from this source only 33.5 percent, and Germany only 15 percent.

- o Both Japan and West Germany enjoy huge trade balances in technology-intensive products not only worldwide, but also with every trading partner in the table.

- o France's position is weak vis-a-vis industrialized countries, but fairly strong and getting stronger in other countries.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Ecconomic and National Security Implications," Draft Report, International Trade Administration, U.S. Department of Commerce. March 1982.

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Table 11

COMPARATIVE TRADE BALANCES (F.O.B) IN DOC1 TECHNOLOGY-INTENSIVE MANUFACTURED PRODUCTS[1] BY COUNTRY AND AREA

(In Billions of U.S. Dollars)

Area	United States 1970	United States 1976	United States 1980	Japan 1970	Japan 1976	Japan 1980	West Germany 1970	West Germany 1976	West Germany 1980	France 1970	France 1976	France 1980
World	4.8	10.2	15.2	2.3	10.5	21.7	2.5	6.8	9.1	.2	1.2	1.7
United States	--	--	--	.7	3.2	3.4	-.3	-.7	-1.2	-.4	-1.2	-2.1
Canada	.9	1.8	.8	.1	.4	.5	-.0	.1	.1	.0	.0	.0
Japan	-.5	-2.7	-3.5	--	--	--	-.1	-.6	-1.4	-.0	-.3	-.8
Western Europe	2.2	4.0	8.2	.3	2.1	5.0	1.8	4.7	7.5	-.1	-.5	-.1
West Germany	.4	.6	1.2	.1	.6	1.6	--	--	--	-.0	-.0	-.0
France	.3	.6	1.1	.0	.2	.4	.2	.8	.9	--	--	--
United Kingdom	.4	.5	1.8	.0	.2	.7	-.0	-.0	-.0	-.1	-.1	-.1
Italy	.2	.5	.7	-.0	.0	.2	.1	.6	1.3	-.1	-.2	-.1
Australia, New Zealand, South Africa	.3	.9	1.6	.1	.7	.9	.2	.4	.6	.1	.2	.2
Eastern Europe	.0	.4	.1	.0	.1	.2	.1	.2	.4	.0	.2	.1
USSR	.0	.1	.1	.0	.1	.2	.0	.2	.2	.0	.0	.1
China	--	.0	.3	.0	.1	.5	.0	.1	.0	.0	.1	.0
OPEC	.3	2.9	3.8	.1	.4	3.4	.1	1.3	1.9	.2	.9	1.7
All Others	1.7	3.8	4.6	.4	1.2	3.0	.5	1.0	1.4	.4	1.2	2.6
NIC's	.2	-.2	.8	.5	1.5	4.5	.1	-.0	-.3	.0	.1	-.1

[1] Includes Medicinal Products (SITC 54), Calculating Machines including Computers (SITC 7114.2), Electrical Machinery, Apparatus and Appliances (SITC 72), Aircraft (SITC 734), Jet Engines (SITC 711.4(2), Professional Scientific and Controlling Instruments (SITC 86). Industries producing these products spend 10 percent or more of their gross product (BEA concept of value added) on R&D, and/or 10 percent or more of their total employees are "natural" scientists, engineers, and technicians.

SOURCE: United Nations

Notes to Table 11:

- o U.S. balances are positive with all trade partners, except Japan.
- o Japan's balances are positive with all trade partners.
- o The United States, Germany, France, and Italy allow trade deficits with NIC's, but not Japan. 54 Percent of U.S. trade balance is derived from trade with Western Europe and 30 percent from trade with "All Other Countries"--largely non-OPEC LDC's.
- o France has the weakest position in high technology trade.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Ecconomic and National Security Implications," Draft Report, International Trade Administration, U.S. Department of Commerce. March 1982.

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Table 12

COMPARATIVE CHANGES IN WORLD (OECD) EXPORT SHARES BY DOC1
CCOMMODITY GROUP FROM 1970 TO 1980

(In Percent)

Commodity Group	United States 1970	United States 1980	United States Change From 1970-1980	Japan 1970	Japan 1980	Japan Change From 1970-1980	West Germany 1970	West Germany 1980	West Germany Change From 1970-1980	France 1970	France 1980	France Change From 1970-1980
Total Merchandise Trade	15.4	12.0	-3.4	8.9	10.6	+1.7	15.7	15.6	-0.1	8.1	9.0	+0.9
Manufacturers (Total)	18.4	16.4	-2.0	8.9	11.0	+2.1	19.8	19.8	0.0	9.1	10.2	+1.1
- Economically Strategic Manufactured Products	14.4	9.9	-4.5	13.3	23.4	+10.1	22.2	21.5	-0.7	9.6	10.6	+1.0
-- Metalworking Machinery	16.5	11.0	-5.5	4.8	16.1	+11.3	34.7	29.4	-5.3	5.6	5.7	+0.1
-- Steel	9.0	5.0	-4.0	21.5	25.6	+4.1	18.4	18.6	+0.2	10.9	11.3	+0.4
-- Road Vehicles	17.4	12.1	-5.3	9.2	23.5	+14.3	23.1	22.3	-0.8	9.3	10.7	+1.4
-- Technology-Intensive Products[1]	23.1	19.9	-3.2	9.7	14.5	+4.8	20.4	19.3	-1.1	1.6	9.0	+1.4
-- High Technology Products[2]	29.9	26.1	-3.8	11.9	15.8	+3.9	14.6	15.7	+1.1	7.2	7.8	+0.6
--- Drugs and Medicinals	17.1	15.8	-1.3	2.7	2.3	-0.4	19.9	17.6	-2.3	9.3	11.6	+2.3
--- Business Machines and Equipment	37.7	37.0	-0.7	8.0	9.9	+1.9	15.1	13.0	-2.1	7.8	7.8	0.0
--- Computers	31.5	35.5	+4.0	11.1	12.3	+1.2	11.2	12.1	+0.9	9.0	7.1	-1.9
-- Electrical and Electronic Machines and Equipment	21.6	18.0	-3.6	10.3	18.7	+8.4	19.5	18.7	-0.8	8.1	9.2	+1.1
--- Telecommunications Equip.	21.9	18.1	-3.8	11.9	23.1	+11.2	15.2	14.6	-0.6	5.5	7.7	+2.2

Table 12 (Continued)

Commodity Group	United States 1970	United States 1980	United States Change From 1970-1980	Japan 1970	Japan 1980	Japan Change From 1970-1980	West Germany 1970	West Germany 1980	West Germany Change From 1970-1980	France 1970	France 1980	France Change From 1970-1980
--- Electronic Components	39.8	27.6	-12.2	6.3	27.0	+20.7	12.5	14.3	+1.8	8.6	8.8	+0.2
--- Consumer Electronics	9.3	9.9	+0.6	49.0	53.0	+4.0	14.3	12.0	-2.3	2.3	5.5	+2.2
--- Jet Engines	40.4	32.0	-8.4	0.1	0.1	0.0	5.4	5.3	-0.1	5.6	7.8[3]	+2.2
--- Aircraft	66.0	53.1	-12.9	0.8	0.4	-0.4	2.9	10.7	+7.8	7.6	9.1	+1.5
--- Scientific Instruments	29.3	26.8	-2.5	8.7	10.4	+1.7	21.5	19.4	-2.1	7.1	8.1	+1.0
-- Technology-Intensive Other Than High Technology Products	20.4	17.3	-3.1	8.8	14.0	+5.2	22.3	20.7	-1.6	7.8	9.4	+1.6
- Not Technology-Intensive Products	10.4	10.1	-0.3	13.7	13.0	-0.7	16.3	16.8	+0.5	9.3	9.9	+0.6
-- Textiles	6.6	9.9	+3.3	18.7	13.7	-5.0	16.0	16.8	+0.8	9.9	9.2	-0.7
-- Apparel	4.6	+5.4	+0.8	11.3	2.2	-9.1	9.7	12.9	+3.2	10.9	11.4	+0.5

[1] Technology-intensive products are produced by industries in which spending on R&D is 5 percent or more of gross product (BEA concept of value added) and/or "natural" scientists, engineers, and technicians comprise 5 percent or more of total employment.

[2] High-technology products are produced by industries in which spending on R&D is 10 percent or more of gross product (value added) and/or "natural" scientists, engineers, and technicians comprise 10 percent or more of total employment.

[3] Average for 1979-1980.

SOURCE: Individual country data as reported to United Nations.

Notes to Table 12:

- o From 1970 to 1980, U.S. industries lost a portion of their export market shares in all major product groups and in most specific product categories <u>except</u> in computers, consumer electronics and the two most important "downmarket" products--textiles and apparel;

- o In the defined product groups, U.S. industries' losses of market shares were greatest in "economically strategic products," (4.5 percentage points), followed by high technology products (loss of 3.8 percentage points) and the technology-intensive products other than high technology (loss of 3.1 percentage points);

- o In specific product lines, U.S. industries' losses were greatest in aircraft (12.9 percentage points), followed by electronic components (12.2 percentage points), jet engines (8.4 percentage points), metalworking machinery (5.5 percentage points), automobiles (5.3 percentage points), and steel (4.0 percentage points);

- o In the "downmarket" not technology-intensive products groups, U.S. industries lost only 3/10 of one percent of their shares and, as already noted, in textiles and apparel U.S. industries improved their shares.

The performance of <u>Japanese industries</u> in the ten year period was for essentially the reverse of the performance of U.S. industries:

- o Of the defined product groups, Japanese industries achieved the greatest gain in "economically strategic products" (10.1 percentage points), followed by a gain of 5.2 percentage points in technology-intensive, and a gain of 3.8 percentage points in high technology products (almost identical with U.S. losses). In the "downmarket" not technology-intensive product group, however, the Japanese lost 7/10 of one percent of their market share;

- o In specific product lines, Japanese industries' gains were relatively greatest in electronic components (gain of 20.7 percentage points), followed by automobiles (gain of 14.3 percentage points), metalworking machinery (gain of 11.3 percentage points), telecommunications equipment (gain of 11.2 percentage points), and steel (further gain of 4 percentage points). However, in textiles Japan lost 5 percentage points of its previous market, and in apparel it lost 9.1 percentage points.

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Over the ten year period, France gained in practically all product groups and specific product lines. Most of its gains, however, were relatively small.

The German score was rather mixed, but a small gain was registered in the high technology product group.

SOURCE: Boretsky, M., "The Threat to U.S. High Technology Industries: Economic and National Security Implications," Draft Report, International Trade Administration, U.S. Department of Commerce. March 1982.

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Table 13

COMPARATIVE CHANGES IN WORLD[1] EXPORT SHARES OF ALL MANUFACTURED PRODUCTS AND DOC1 TECHNOLOGY-INTENSIVE PRODUCTS[2] FROM 1955 to 1980

(In Percent)

Country and Product Group	1955	1960	1970	1980	Change From 1955-1980
United States					
All Manufactured Products	25.9	22.8	18.4	16.4	-9.5
Technology-Intensive Products	35.5[3]	27.6	23.1	19.9	-15.6
Japan					
All Manufactured Products	4.8	6.5	8.9	11.0	+6.2
Technology-Intensive Products	1.8[3]	4.2	9.7	14.5	+12.7
West Germany					
All Manufactured Products	14.6	18.2	19.8	19.8	+5.2
Technology-Intensive Products	17.6[3]	21.2	20.4	19.3	+1.7
France					
All Manufactured Products	8.8	9.1	8.3	10.2	+1.4
Technology-Intensive Products	6.4[3]	7.7	7.6	9.0	+2.6

1 "World" exports are defined as the sum of the exports from 14 or 15 most important OECD (industrial) countries. The listed countries' percentages differ very little depending on whether the sume of the 14 or 15 countries is used in the calculation.

2 For definition of technology-intensive products, see Table 6.

3 1954.

SOURCES: United Nations, OECD, National Institute of Economic and Social Research (London), and U.S. Department of Commerce.

Table 14

U.S. AND JAPANESE HIGH TECHNOLOGY TRADE WITH THE WORLD
(In billions of U.S. dollars)

	UNITED STATES			JAPAN		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	4.6	1.0	3.6	0.6	0.6	0.1
1963	4.7	1.1	3.6	0.7	0.7	0.1
1964	5.4	1.4	4.0	0.9	0.8	0.2
1965	6.2	1.8	4.4	1.3	0.7	0.6
1966	6.9	2.6	4.3	1.7	0.8	0.9
1967	8.0	2.7	5.2	1.9	1.0	0.9
1968	9.5	3.4	6.1	2.5	1.2	1.3
1969	10.6	4.0	6.6	3.2	1.4	1.8
1970	12.2	5.0	7.3	4.0	2.0	1.9
1971	13.1	5.8	7.4	4.8	2.2	2.7
1972	14.0	7.4	6.7	6.1	2.5	3.7
1973	18.8	9.4	9.4	8.0	3.6	4.4
1974	26.4	11.7	14.8	11.1	5.0	6.1
1975	27.8	11.4	16.4	11.1	4.2	7.0
1976	31.0	15.4	15.7	14.2	4.9	9.4
1977	33.2	17.8	15.4	17.6	5.3	12.2
1978	40.2	23.5	16.8	23.2	6.9	16.4
1979	51.0	27.2	23.7	26.1	9.3	16.7
1980	63.3	32.8	30.5	32.5	11.2	21.3

NOTE: The high tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a cost of merchandise ("free free along side," or fas) basis prior to 1977 and on a cost of the merchandise, insurance and freight (cif) basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 15

WEST GERMAN AND FRENCH HIGH TECHNOLOGY TRADE WITH THE WORLD
(In billions of U.S. dollars)

	WEST GERMANY			FRANCE		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	2.7	1.0	1.7	1.2	0.9	0.3
1963	3.1	1.1	2.0	1.3	1.0	0.2
1964	3.5	1.3	2.1	1.5	1.3	0.2
1965	3.9	1.7	2.1	1.7	1.4	0.4
1966	4.5	1.9	2.6	2.0	1.7	0.3
1967	5.0	2.1	3.0	2.3	2.0	0.3
1968	5.7	2.5	3.2	2.4	2.3	0.1
1969	6.7	3.2	3.6	2.9	2.9	0.0
1970	8.1	4.2	3.9	3.3	3.3	-0.0
1971	9.1	4.9	4.2	3.7	3.7	-0.0
1972	10.8	5.6	5.2	4.6	4.8	-0.2
1973	15.7	7.7	8.0	6.4	6.6	-0.2
1974	21.5	9.9	11.5	8.6	8.8	-0.2
1975	20.3	10.8	9.5	9.8	8.7	1.0
1976	24.1	13.3	10.9	11.3	10.5	0.8
1977	27.6	15.7	11.9	12.9	11.6	1.3
1978	33.5	20.0	13.5	16.3	14.5	1.8
1979	41.9	26.8	15.1	21.9	19.2	2.7
1980	46.5	30.8	15.7	23.8	23.2	0.6

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

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Table 16

INDUSTRIAL-COUNTRY AND OECD HIGH TECHNOLOGY TRADE
(In billions of U.S. dollars)

	14 INDUSTRIAL COUNTRIES			OECD		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	15.3	9.1	6.2	15.4	9.9	5.5
1963	17.0	10.4	6.6	17.1	12.1	5.0
1964	19.5	12.3	7.2	19.7	14.3	5.4
1965	22.2	13.8	8.4	22.5	16.2	6.4
1966	25.4	16.3	9.1	25.8	19.0	6.7
1967	28.2	18.5	9.8	28.7	21.4	7.3
1968	32.9	21.7	11.2	33.5	24.9	8.5
1969	38.1	26.2	11.9	38.8	29.8	9.0
1970	44.6	31.5	13.1	45.5	35.8	9.7
1971	50.3	35.4	14.9	51.3	39.9	11.4
1972	59.0	42.1	16.8	60.3	47.7	12.6
1973	79.2	57.3	21.9	81.2	65.3	15.9
1974	108.9	75.4	33.5	112.0	86.3	25.8
1975	112.3	75.5	36.9	115.3	86.5	28.8
1976	129.0	88.9	40.1	132.8	100.9	31.9
1977	145.6	101.4	44.1	150.0	114.4	35.6
1978	181.1	128.7	52.4	186.6	143.6	43.0
1979	224.0	165.0	59.0	231.2	184.4	46.8
1980	264.9	194.6	70.3	274.7	215.9	58.9

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

The 14 industrial countries are: Austria, Belgium, Canada, Denmark, France, West Germany, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, and United States. Belgium and Luxembourg report trade data as a unit, thus the reference to 14, rather than 15, countries. These countries account for approximately 80 percent of world trade in manufactured products.

All data are on a SITC REV1 basis as reported by the United Nations on the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

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Table 17

U.S. HIGH TECHNOLOGY TRADE WITH JAPAN
(In billions of U.S. dollars)

YEAR	EXPORTS	IMPORTS	BALANCE
1962	0.2	0.1	0.1
1963	0.3	0.1	0.1
1964	0.3	0.2	0.1
1965	0.4	0.3	0.1
1966	0.5	0.4	0.0
1967	0.5	0.5	0.1
1968	0.6	0.6	-0.1
1969	0.8	0.9	-0.1
1970	1.1	1.2	-0.1
1971	1.1	1.4	-0.3
1972	1.2	1.9	-0.7
1973	1.6	2.3	-0.7
1974	2.3	2.7	-0.4
1975	1.7	2.5	-0.8
1976	2.0	4.1	-2.0
1977	2.1	4.8	-2.7
1978	2.8	6.2	-3.4
1979	4.1	6.6	-2.5
1980	4.9	7.7	-2.8

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 18

U.S. HIGH TECHNOLOGY TRADE WITH WEST GERMANY AND FRANCE
(In billions of U.S. dollars)

	WEST GERMANY			FRANCE		
YEAR	EXPORTS	IMPORTS	BALANCE	EXPORTS	IMPORTS	BALANCE
1962	0.2	0.1	0.0	0.2	0.1	0.1
1963	0.2	0.2	0.0	0.2	0.0	0.1
1964	0.2	0.2	0.0	0.2	0.1	0.1
1965	0.4	0.2	0.2	0.3	0.1	0.3
1966	0.4	0.3	0.1	0.4	0.1	0.2
1967	0.5	0.3	0.2	0.4	0.1	0.3
1968	0.6	0.4	0.1	0.5	0.1	0.3
1969	0.7	0.5	0.2	0.5	0.1	0.3
1970	1.0	0.6	0.3	0.6	0.2	0.4
1971	1.0	0.7	0.3	0.6	0.2	0.4
1972	1.1	0.8	0.3	0.7	0.2	0.4
1973	1.3	1.0	0.2	1.0	0.3	0.6
1974	1.5	1.3	0.2	1.2	0.4	0.7
1975	1.7	1.1	0.6	1.1	0.5	0.7
1976	1.8	1.3	0.5	1.4	0.7	0.7
1977	2.0	1.5	0.5	1.5	0.7	0.8
1978	2.7	2.2	0.5	1.9	0.9	0.9
1979	3.3	2.5	0.9	2.4	1.2	1.2
1980	4.1	2.7	1.3	3.3	1.5	1.7

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 19

SHARES OF 14 INDUSTRIAL-COUNTRY HIGH TECHNOLOGY EXPORTS
(In percent)

YEAR	U.S. SHARE	JAPANESE SHARE	WEST GERMAN SHARE	FRENCH SHARE
1962	30.3	4.1	17.6	7.7
1963	27.8	4.4	18.5	7.6
1964	27.7	4.8	17.9	7.6
1965	28.0	5.9	17.4	7.8
1966	27.3	6.7	17.8	8.0
1967	28.2	6.8	17.8	8.0
1968	28.9	7.6	17.3	7.4
1969	27.9	8.5	17.7	7.6
1970	27.4	8.9	18.3	7.4
1971	26.1	9.6	18.0	7.4
1972	23.8	10.4	18.3	7.8
1973	23.8	10.1	19.9	8.1
1974	24.2	10.2	19.7	7.9
1975	24.8	9.9	18.1	8.7
1976	24.1	11.0	18.7	8.8
1977	22.8	12.1	18.9	8.8
1978	22.2	12.8	18.5	9.0
1979	22.7	11.6	18.7	9.8
1980	23.9	12.3	17.5	9.0

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

The "14 industrial countries" include: Austria, Belgium, Canada, Denmark, France, West Germany, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, and United States. Belgium and Luxembourg report trade data as a unit, thus the reference to 14 rather than 15 countries. These countries account for approximately 80 percent of world trade in manufactured products.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

Table 20

SHARES OF THIRD-COUNTRY MARKETS
(In percent)

YEAR	U.S. SHARE	JAPANESE SHARE	GERMAN SHARE	FRENCH SHARE	4 COUNTRY SHARE
1962	38.4	4.6	8.5	7.2	58.7
1963	35.3	5.0	8.5	7.8	56.6
1964	35.6	5.0	8.8	8.3	57.8
1965	36.2	4.0	10.1	8.0	58.3
1966	36.2	4.2	9.8	8.8	58.9
1967	37.5	4.7	9.6	9.2	61.0
1968	38.8	4.8	10.0	9.4	63.1
1969	38.2	5.2	11.4	10.3	65.1
1970	38.6	6.4	13.2	10.6	68.8
1971	36.8	6.0	13.6	10.5	66.9
1972	33.8	5.9	13.5	11.5	64.8
1973	33.4	6.3	13.7	11.7	65.1
1974	32.8	6.2	12.3	10.9	62.1
1975	33.1	4.9	12.8	10.4	61.2
1976	33.0	5.2	14.1	11.1	63.4
1977	31.3	5.0	14.8	10.9	62.1
1978	30.9	5.3	15.3	11.1	62.6
1979	31.8	5.8	16.7	12.0	66.4
1980	32.9	5.8	16.0	12.1	66.7

Note: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

OECD exports to countries other than the United States, Japan, West Germany, and France were used as a proxy for third country markets. A country's share of this market is its exports to the world, net of exports to the other three countries, divided by the third country market proxy.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

TABLE 21

U.S. SHARES OF WORLD* MERCHANDISE EXPORTS

(Volume Share in 1960 U.S. Dollars)

(In percent)

YEAR	VALUE SHARE	VOLUME SHARE
1960	18.0	18.0
1961	17.5	17.2
1962	17.3	16.9
1963	17.0	17.0
1964	17.3	17.8
1965	16.5	16.2
1966	16.6	16.4
1967	16.4	15.9
1968	16.1	15.3
1969	15.4	14.5
1970	15.2	14.4
1971	13.9	13.3
1972	13.2	13.7
1973	13.6	15.0
1974	12.7	15.1
1975	13.5	15.5
1976	12.7	15.1
1977	11.6	13.9
1978	12.0	14.6
1979	12.0	15.4
1980	11.8	16.3
1981	12.7	16.1

*The World is defined as all IMF member countries.

Source: International Monetary Fund, "International Financial Statistics", various issues.

TABLE 22

U.S. SHARES OF 14 INDUSTRIAL-COUNTRY*
EXPORTS OF HIGH TECHNOLOGY PRODUCT GROUPS

(In percent)

PRODUCT	1965	1970	1980
Aircraft and parts	50.0	60.8	50.5
Office, computing, and accounting machines	35.7	38.1	36.2
Electrical equipment and components	23.8	22.1	17.1
Optical and medical instruments	20.0	17.9	15.1
Drugs and medicines	23.1	16.7	16.1
Plastic and synthetic materials	20.0	12.5	13.9
Engines and turbines	31.3	28.1	28.3
Agricultural chemicals	16.7	20.0	30.3
Professional and scientific instruments	35.7	33.3	30.6
Industrial Chemicals	24.4	22.7	17.6

* The 14 industrial-country group includes: Austria, Belgium-Luxemborg, Canada, Denmark, France, West Germany, Italy, Japan, Netherlands, Norway, Sweden, Switzerland, United Kingdom, and United States

Source: UN Series D Trade Data

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TABLE 23

INDICES OF REVEALED COMPARATIVE ADVANTAGE FOR THE
UNITED STATES, JAPAN, WEST GERMANY AND FRANCE, 1965 AND 1980

PRODUCT GROUP	UNITED STATES		JAPAN		WEST GERMANY		FRANCE	
	1965	1980	1965	1980	1965	1980	1965	1980
1. Aircraft and parts	2.28	2.73	0.05	0.03	0.23	0.61	0.72	0.66
2. Office, computing; and accounting machines	1.47	1.96	0.24	0.89	1.23	0.82	1.25	0.82
3. Electrical equipment and components	1.05	0.92	1.13	2.32	1.13	1.03	0.91	0.92
4. Optical and medical instruments	0.82	0.82	1.58	2.37	1.29	0.92	0.70	0.68
5. Drugs and medicines	0.88	0.88	0.36	0.21	1.17	1.10	1.28	1.26
6. Plastic and synthetic materials	0.91	0.75	1.16	0.69	1.31	1.43	0.94	1.02
7. Engines and turbines	1.35	1.53	0.44	1.04	1.19	1.09	0.57	0.88
8. Agricultural Chemicals	0.72	1.66	1.11	0.38	1.28	0.78	0.98	0.67
9. Professional and scientific instruments	1.48	1.67	0.53	0.58	1.26	1.11	0.60	0.91
10. Industrial Chemicals	1.09	0.95	0.88	0.62	1.38	1.28	1.08	1.23
11. Radio and Television receiving equipment	0.31	0.34	6.37	5.01	1.27	0.99	0.27	0.15
12. Road motor vehicles	0.97	0.67	0.67	2.17	1.80	1.37	0.97	1.11
13. Other chemicals	1.09	1.23	0.25	0.31	1.18	1.19	1.62	1.45
14. Electrical machinery	0.84	0.88	1.06	1.38	1.51	1.27	0.82	1.97
15. Other transportation equipment	1.14	1.01	0.96	1.87	1.44	1.22	0.92	1.04
16. Textile fibers, yarns, and fabrics	0.63	0.93	2.27	1.18	0.70	0.99	1.36	1.01
17. Non-electrical machinery	1.19	1.08	0.55	0.96	1.59	1.39	0.68	0.83
18. Non-ferrous metals, misc. metal products	0.63	0.63	0.98	0.72	0.99	0.94	0.83	0.92

Continued on the next page

TABLE 23
(Continued)

INDICES OF REVEALED COMPARATIVE ADVANTAGE FOR THE
UNITED STATES, JAPAN, WEST GERMANY AND FRANCE, 1965 AND 1980

PRODUCT GROUP	UNITED STATES		JAPAN		WEST GERMANY		FRANCE	
	1965	1980	1965	1980	1965	1980	1965	1980
19. Misc. manufactured products	0.77	0.81	1.56	0.62	1.16	1.12	1.11	0.96
20. Fuels	1.00	0.53	0.10	0.06	1.16	0.53	0.92	0.98
21. Apparel, footwear, and accessories	0.32	0.32	2.09	0.23	0.68	0.86	1.52	1.32
22. Iron and Steel	0.36	0.28	2.35	2.32	1.22	1.17	1.48	1.28
23. Foods, beverages, and tobacco	1.42	1.54	0.34	0.13	0.21	0.52	1.35	1.68
24. Leather and rubber products	0.72	0.48	1.23	1.26	1.00	1.11	1.93	1.76
25. Animal and vegatable oils and fats	2.53	2.06	0.49	0.20	0.49	0.98	0.42	0.83
26. Wood and paper products	0.68	1.06	0.47	0.22	0.28	0.55	0.54	0.64

Source: UN Series D Trade Data

Note: The index is a ratio of a country's world* market share in the product group to the country's total market share.

* The world is defined as the 14 industrial countries.

Table 24

IMPORTS OF HIGH TECHNOLOGY PRODUCTS
RELATIVE TO HIGH TECHNOLOGY EXPORTS

(In percent)

YEAR	UNITED STATES	JAPAN	WEST GERMANY	FRANCE
1962	22.2	88.7	38.0	73.9
1963	23.5	89.8	36.1	80.8
1964	26.7	81.3	38.5	85.4
1965	29.2	52.8	44.6	79.4
1966	37.3	46.7	41.6	83.5
1967	34.2	52.4	40.9	87.2
1968	35.9	47.2	43.2	94.9
1969	38.0	44.7	47.0	98.9
1970	40.5	51.6	51.6	101.4
1971	44.0	44.7	53.6	100.7
1972	52.5	40.2	51.8	103.9
1973	49.9	44.6	49.0	102.8
1974	44.1	44.7	46.2	102.4
1975	41.0	37.4	53.1	89.4
1976	49.6	34.1	55.0	92.7
1977	53.7	30.3	57.0	90.2
1978	58.3	29.5	59.8	88.8
1979	53.5	35.8	63.9	87.6
1980	51.8	34.5	66.2	97.6

NOTE: The ratios are calculated as the country's imports of the products divided by its exports of the products. The ratios are, then, imports as a percentage of exports.

The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 25

HIGH TECHNOLOGY EXPORT SURPLUS SHARES OF HIGH TECHNOLOGY EXPORTS

(In percent)

YEAR	UNITED STATES	JAPAN	WEST GERMANY	FRANCE
1962	77.8	11.3	62.0	26.1
1963	76.5	10.2	63.9	19.2
1964	73.3	18.7	61.5	14.6
1965	70.8	47.2	55.4	20.6
1966	62.7	53.3	58.4	16.5
1967	65.8	47.6	59.1	12.8
1968	64.1	52.8	56.8	5.1
1969	62.0	55.3	53.0	1.1
1970	59.5	48.4	48.4	-1.4
1971	56.0	55.3	46.4	-0.7
1972	47.5	59.8	48.2	-3.9
1973	50.1	55.4	51.0	-2.8
1974	55.9	55.3	53.8	-2.4
1975	59.0	62.6	46.9	10.6
1976	50.4	65.9	45.0	7.3
1977	46.3	69.7	43.0	9.8
1978	41.7	70.5	40.2	11.2
1979	46.5	64.2	36.1	12.4
1980	48.2	65.5	33.8	2.4

NOTE: The high-tech definition used here is the DOC2 definition, excluding radio- and TV- receivers.

The export surplus shares are the country's trade balance (exports - imports) divided by its exports.

All data are on a SITC REV1 basis as reported by the United Nations in the annual UN SERIES D DATA TAPES. These tapes do not include revisions later made by the reporting countries. The data do not include reported reexports.

The U.S. import series is on a fas basis prior to 1977 and on a cif basis from 1977 to 1980. Estimates of the effects of this reporting change are not available at the level of disaggregation necessary to revise the series reported here. On an aggregate level the change to a cif basis has been estimated to increase the reported value of imports by approximately 5 percent.

Table 26

HIGH TECHNOLOGY SHARE OF U.S. MANUFACTURES SHIPMENTS AND EXPORTS, EXPORT SURPLUS SHARE OF EXPORTS, AND IMPORT SHARE OF APPARENT CONSUMPTION, THE DOC3 DEFINITION[1]

(In percent)

High-Technology Manufactures

Year	Share of Total Manufactures			Export Surplus Share of Exports	Import Share of Apparent Consumption*
	Shipments	Exports	Imports		
1974	13.2	29.3	13.0	55.8	8.3
1975	12.5	28.3	14.0	59.6	8.0
1976	12.5	28.9	16.2	49.8	9.5
1977	12.4	29.3	15.8	45.7	9.5
1978	12.8	30.3	16.5	42.0	10.9
1979	13.3	30.0	16.3	47.7	10.5
1980	14.2	31.5	17.5	50.3	11.2
1981	13.9	32.2	18.8	45.0	11.9

[1] See Table 8.

* High technology manufactures shipments, less exports, plus imports.

SOURCE: Davis, L.A. "Technology Intensity of U.S. Output and Trade," Office of Trade and Investment Analysis, U.S. Department of Commerce, February 1982.

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Table 27

DECLINE IN THE WORLDWIDE POSITION OF THE LARGEST U.S. COMPANIES IN TEN INDUSTRIES, FROM 1959 TO 1978

Industry	Number of the World's Largest Companies in 10 Industries	Number of U.S. Companies		Sales of U.S. Companies as % of Sales of All Companies	
		1959	1978	1959	1978
All Ten Industries[2] [3]	117	84	60	78.5	51.0
- High Technology Industries[1]	46	34	25	78.8	47.4
-- Pharmaceuticals[2]	12	9	7	61.6	35.0
-- Chemicals[2]	12	7	4	66.3	31.9
-- Electronic Appliances	14	8	6	75.6	46.9
-- Aerospace	11	10	9	95.4	90.1
- Others	71	50	35	78.3	53.2
-- General Machinery	12	7	6	61.7	51.8
-- Automotive	11	5	3	84.3	59.7
-- Metal Products	11	7	5	66.8	43.2
-- Metal Manufacturing	13	11	4	89.9	32.4
-- Paper and Paper Products	10	9	7	92.2	70.6
-- Food Products	14	11	10	66.6	55.7

[1] The high technology category comprises here slightly different industries from those included in our high technology category in Tables 1-6. We consider chemicals other than pharmaceuticals technology-intensive rather than high technology.

[2] Two German companies, Hoechst and Bayer, which are among the top producers in the chemical and pharmaceutical industries, are counted only once in the totals.

SOURCE: National Planning Association, New International Realities, Volume V, Number 1, July 1980.

Table 28

GROWTH OF R&D EXPENDITURES IN 1975 PRICES FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE: 1964-70, 1970-79

(Percentage Change)

	1964-1970	1970-1979
United States	10	15
Japan	129	81
Germany	90	44
France	41	32

SOURCE: OECD, Science and Technology Indicators Unit

Table 29

R&D EXPENDITURES AS A SHARE OF GROSS DOMESTIC PRODUCT FOR THE UNITED STATES, JAPAN, WEST GERMANY, AND FRANCE: 1964-79, SELECTED YEARS

(In percent)

	1964	1970	1975	1979
United States	3.1	2.8	2.4	2.4
Japan	1.5	1.8	1.9	2.0
Germany	1.4	2.1	2.2	2.3
France	1.8	1.9	1.8	1.8

SOURCE: OECD, Science and Technology Indicators Unit

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Table 30

SHARE OF BASIC RESEARCH IN TOTAL R&D SPENDING FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE: 1964 AND 1977

(In percent)

	1967	1977
United States	13	13
Japan	10	16
Germany	13	20
France	18	21

SOURCE: OECD, Science and Technology Indicators Unit

Table 31

GROWTH OF BUSINESS R&D FUNDING IN 1975 PRICES FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE 1964-70, 1971-78

(Percent change)

	1964-1970	1971-1978
United States	42	31
Japan	-	48
Germany	89	21
France	59	36*

*For France, the estimate covers the period 1970-1977 since data were not available for 1978.

SOURCE: OECD, Science and Technology Indicators Unit

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Table 32

GROWTH OF R&D PERFORMANCE OF SELECTED INDUSTRIES IN 1975 PRICES, FOR THE UNITED STATES, JAPAN, WEST GERMANY, FRANCE: 1967-77

(In percent)

	United States	Japan	West Germany	France
Electronic Equipment Components	-	54	-	125
Aircraft	-28	-	170	-16
Motor Vehicles	-	212	79	120
Ferrous Metals	0	153	-60	21
Non-ferrous Metals	60	34	9	65
Instruments	73	272	83	-70
Machinery	66	175	62	-24

SOURCE: OECD, Science and Technology Indicators Unit

Table 33

CHANGE IN GOVERNMENT R&D EXPENDITURES IN 1975 PRICES FOR THE UNITED STATES, JAPAN, WEST GERMANY AND FRANCE: 1964-70, 1970-78

(In percent)

	1964-1970	1970-1978
United States	-6	-3
Japan	98	66
Germany	76	30
France	32	6*

*For France the estimate is for the period 1970-1977.

SOURCE: OECD, Science and Technology Indicators Unit

Table 34

COMPARATIVE LEVELS OF INDUSTRIAL R&D EFFORT[1]
SELECTED YEARS, 1964-79

Country	1964 R&D Millions of U.S. Dollars	1964 R&D % of U.S. Total	1971 R&D Millions of U.S. Dollars	1971 R&D % of U.S. Total	1979 R&D Millions of U.S. Dollars	1979 R&D % of U.S. Total
United States	13,512	100.0	18,320	100.0	37,958	100.0
Japan	573	4.2	4,182	22.8	9,518	25.1
West Germany	972	7.2	3,247	17.7	7,535	19.9
France	925	6.8	2,084	11.4	4,664	12.3
Sum of the Three Foreign Countries	2,479	18.3	9,513	51.9	21,717	57.3

[1] "Industrial" R&D is equated with R&D performed in business enterprises, whatever the source of funds.

SOURCES: Data on R&D in respective countries' currencies obtained from OECD, Directorate for Science, Technology and Industry (Science and Technology Indicators, 1963-1979, January 1982) converted into U.S. dollars by means of purchasing power parities at GDP level. The estimates of these parities are consistent with the benchmark estimates provided by Irving B. Kravis, et al, in A System of International Comparisons of Gross Product and Purchasing Power, Phase I, The John Hopkins University Press, 1975, Idem, Phase II, 1978, and the relative changes in GDP deflators and exchanges over time.

Table 35

TRENDS IN NUMBERS OF SCIENTISTS AND ENGINEERS EMPLOYED IN R&D, 1970-1979

	1970		1979		
Countries	(thousands)	As % of total for 4 countries	(thousands)	As % of total for 4 countries	Percent Change 1970-1979
United States	546.5	63.6%	628.6	57.3	18.0%
Japan	172.0	20.0%	273.1[1]	24.9%	58.8%[2]
West Germany	82.5	9.6%	122.0	11.1%	47.9%
France	58.5	6.8%	73.0	6.7%	24.8%
Total-Four Countries	859.5	100.0 %	1096.7	100.0%	27.6%

[1] 1978.
[2] 1970-1978.

SOURCES: "Science and Engineering Employment" 1970-1980, Special Report, NSF, 1981
"Science Indicators", NSF, 1981.
"International Statistical Year", several years, OECD.

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APPENDIX C

SUMMARY OF THE CHANGING COMPETITIVE SITUATION IN SELECTED HIGH TECHNOLOGY SECTORS

AIRCRAFT, THE JET TRANSPORT INDUSTRY

The U.S. civil aircraft industry has traditionally dominated world markets, as late as the mid-1970s, U.S. manufacturers held 95 percent of the world's orders for airliners. Foreign competition has intensified since 1975, however, and by 1981 the European Airbus had captured 26 percent of the jet aircraft market. The decline in U.S. dominance is primarily due to substantially increased development efforts by foreign governments and a simultaneous decline in U.S. government R&D support. The major competitive challenge currently comes from the European consortium Airbus Industries. But, the Japanese industry is rapidly gaining expertise in engines and parts.

ROLE OF RESEARCH AND DEVELOPMENT

The historical U.S. dominance of the jet transport market has been, to a large extent, the result of technological leadership. The expansion of foreign R&D capabilities, much of it government funded, has challenged U.S. technological leadership.

The relative level of U.S. aerospace R&D funding has steadily declined, while foreign nations have increased their R&D expenditures. Although industry-funded R&D has increased, it accounts for only one-fourth of total aerospace R&D expenditures and could not compensate for the decline in federal funding. The average annual level of U.S. government-sponsored R&D was 32 percent lower in the 1970s than in the 1950s. The decline continued in 1980 when total U.S. expenditures fell 13 percent from their 1979 levels.

INCREASING COMPETITIVE CHALLENGE

In 1979 the Airbus was second to Boeing in sales and had as many orders as McDonnell Douglas and Lockheed combined. The consortium is composed of Aerospatiale of France, Deutsch Airbus (MBB and VFW-Fokker) of Germany, British Aerospace and CASA of Spain. With the exception of Fokker, all of the companies are fully or partially government owned.

Both the German and French governments have heavily funded the Airbus program. The Germans estimate they will have to invest over $1.1 billion through 1985. The French government had invested one billion dollars through 1980, and has budgeted $1.2 billion in additional funding through 1985. The Chairman of Fokker summed up the Airbus dependence on government funding in the July 1979 issue of Interavia magazine: "It's a delicate subject - Airbus. It's a successful aircraft, but it requires basic support from the German and French governments. As you have written yourself 10 million Deutsche marks ($4.2 million) per aircraft."

The U.S. industry faces strong competition for the jet transport market of the 1980s. To meet the expected demand of the next decade, U.S. companies are offering a mixture of new designs and advanced versions of existing designs that incorporate the most advanced technology. Europe's Airbus will launch two new models which, in light of recent Airbus successes, must be expected to be highly competitive. Moreover, as the highest growth markets are predicted to be outside the United States, this could prove to be an asset for foreign manufacturers.

An additional challenge can be expected from Japan in the future, though largely in parts and engines. The Japanese are currently involved in numerous joint development and production programs with major U.S. and European manufacturers. Involvement in these programs has enabled the Japanese to acquire the state-of-the-art expertise necessary to increase their role in the market in the 1980s.

ADDITIONAL REFERENCES: Bureau of Industrial Economics. 1982 U.S. Industrial Outlook. U.S. Department of Commerce, 1982.

Civil Aviation Advisory Group Aerospace Technical Advisory Council. "The Challenge of Foreign Competition to the U.S. Jet Transport Manufacturing Industry," Aerospace Industries Association of America, The Aerospace Research Center, Washington, D.C., December 1981.

SPACE

Space commercialization is a matter of economic necessity. Yet the United States' lead in space is slipping. The U.S.S.R. launches many more vehicles each year than the United States. France, in cooperation with its European neighbors, is rapidly developing a launch capability that directly challenges the United States monopoly in launching communication satellites, the only current area of space activity that is commercially self-sustaining. Most of the satellites themselves are still made by U.S. companies, in part because of the tie-in with U.S. launch vehicles.

Space launch activity in the United States has been and is the province of the U.S. government. Civil launches are handled by the National Aeronautics and Space Administration (NASA), and military launches are the responsibility of the Air Force. Although the only U.S. manned space activity in the near future will be the use of crews on the Space Shuttle, planning has begun for the establishment of a permanent manned presence in space.

COMSAT was created by statute to move the commercialization of space communications into the private sector. COMSAT is a member of INTELSAT, the international communications satellite consortium. Commercialization has been largely successful, with the launch of those satellites dependent on NASA. Indeed, NASA has handled almost all civil space launches outside of the Soviet bloc countries. This near-monopoly of service is ending. INTELSAT has already scheduled satellites for launch on Europe's Ariane vehicle in the mid-1980's, as have two U.S. firms.

The European Space Agency (ESA) was created as the European answer to NASA. As of the end of 1980, only one European-launched spacecraft had attained earth orbit or beyond, while 756 U.S.-launched spacecraft attained earth orbit. The number of U.S. launches has fallen steadily -- from 26 in 1976 to 13 in 1980. Japan, on the other hand, has launched at the increasing rate of 1, 2, and 3 per year; and Europe, with its Ariane launch vehicle, is also increasing its commercial as well as military launches each year.

The Space Shuttle will carry national security payloads that may claim priority on the basis of national security requirements. Normally, payload launch dates are negotiated on a first-come, first-served basis.

The estimated requirements for space launch services by the mid-1980s will exceed the capacity of the available shuttles by a factor of two. An understanding of this problem has surfaced outside the United States, and the French have gone on a marketing campaign to secure the overflow traffic for Ariane launches.

At a time of increasing space commercialization, the United States stands in an uncomfortable competitive position, attributable to:

- o phasing down U.S. dependence on expendable launch services;
- o a potentially inadequate capacity to meet future demand for space launch services, whether military or civil in nature; if expendable launch vehicles are phased out and no additions are made to the Shuttle fleet;
- o high-priced expendable launch services because of the full cost recovery policy and because improvements to expendable launch vehicles have slowed. The latter is the result of the assumption that all launch services would be handled by the Shuttle at reduced launch costs per satellite;
- o French Government economic policies and subsidies, which result in prices for Ariane expendable launch services being roughly 20-25 percent below the prices quoted by NASA for commercial expendable launch vehicles and services, but above quoted Shuttle prices;
- o Arianespace, an independent quasi-commercial organization, can offer financing terms more favorable to the customer than those presently available through NASA;
- o the French plan for rapid evolution of the Ariane launch vehicle to meet future needs of the commercial satellite industry;
- o the Japanese pattern of putting up satellites, quietly, with little fanfare, aided in part by the transfer of Delta launch vehicle technology. In time, they could assume a launch support role for commercial satellites, but our agreement with Japan includes prohibitions on their competitive activities for launch services suppliable by U.S. system.

ECONOMIC IMPLICATIONS

Pricing of U.S. launches is artificial, set by Government policy rather than as the result of private negotiation between launch customer and commercial launch vechile supplier. U.S. companies will secure the services needed for commercial launches on the basis of price, lift capability, and launch date.

U.S. Shuttle launches will be used first by the military and other U.S. Government agencies. As for commercial payloads, there is some concern about schedule preemption by military payloads (for national security) and, as the French develop a reputation for the launch services, more satellite owners, U.S. and foreign, will begin to buy such services overseas. This has serious potential implications for the multi-billion dollar satellite construction business, now dominated by U.S. companies.

U.S. Government policy and budget constraints have limited the speed of commercialization of space, in part because of pressures on the NASA budget. Commercial launch vehicle services are available only through NASA and the enormous cost and technical risk of space commercialization has deterred investment by the private sector in other areas, except in cooperation with government. Although several ventures to provide launch services commercially have been proposed -- both for operation of the Shuttle and for expendable launch vehicles -- it is unlikely that the private sector could enter the commercial market in competition with NASA.

ROLE OF NATIONAL GOVERNMENTS

In France, the government assumes the responsibility for basic research and some application development. When the point of commercialization arrives, the technology is turned over to the quasi-public companies for marketing, distribution and overall commercialization. Arianespace has stockholders from several governments in Europe, plus private individuals, private firms, and private banks.

In the United States, launch vehicle services (except for upper stages) are totally handled by the Government, using the manufacturers as prime or subcontractors to provide the mechanical services needed for specific launches. Although production and sales of communication satellites are totally commercialized, the companies have little, if any, role in either developing evolutionary/revolutionary launch vehicles or in pricing vehicles and services, except for upper stages. Other areas of space commercialization remain to be explored.

ADDITIONAL REFERENCE: Office of Technology Assessment, Civilian Space Policy and Applications, Congress of the United States, 1982.

COMPUTERS AND SOFTWARE

The United States retains broad leadership in computer hardware and software production and technology. The high growth areas in the computer industry today are personal computers, office automation, software, and services..

HARDWARE

While mainframe production is dominated by relatively few large companies, many smaller companies have entered the smaller, personal computer market. Many of the larger companies are also giving added emphasis to the micro- and minicomputer market, where growth rates are well above those in the mainframe sector.

The major foreign competitor in computer hardware is Japan, whose companies have products competitive with a range of U.S. equipment, including large scale general purpose processors, magnetic disk storage and printers. In the large scale systems sector, Japanese firms have produced equipment equalling or exceeding U.S. capabilities, relying on their growing strength in high speed logic, and memory components.

Japan has targeted the large scale scientific processing sector, the so-called supercomputers, where U.S. firms have been unchallenged leaders. The leading Japanese computer firm recently announced a supercomputer which it claims rivals the performance of current U.S equipment. The Japanese began a 10-year joint government-industry effort to produce a "5th generation" computer system, by which they hope to leapfrog U.S. leadership in computer technology.

SOFTWARE

Despite impressive growth in sales over the past few years, software productivity has not kept up with the expanded use of computers, especially microprocessor-based systems. Software now accounts for a growing percentage of a typical computer's cost, while hardware's share, which used to account for the bulk of a system's cost, is steadily declining.

A shortage of workers with key skills has been an important contributor to the rising cost of software. A 1981 study reported 54,000 job openings for graduates with degrees in computer science but only 13,000 graduates with the necessary skills to fill those positions.

There have been significant changes in the software sector, which may help ease the software bottleneck. For example, in the microcomputer sector, there are now several standard operating systems and high-level programming languages that a growing number of suppliers are implementing on their equipment. Software producers are also able to increase their efficiency by using a range of programming and automated software development. The Japanese, who traditionally have lagged behind the U.S. industry in software, have increased their research in this sector, aided by government funding.

ADDITIONAL REFERENCES: Bureau of Industrial Economics, 1982 U.S. Industrial Outlook, U.S. Department of Commerce, 1982.

Science. Vol. 215, February 12, 1982, American Association for the Advancement of Science, Washington, D.C. This issue is devoted to computers and electronics.

SEMICONDUCTORS

OVERVIEW

Semiconductors, devices which modify electrical signals, are essential in industrial electronic equipment (37% of 1979 sales that amounted to $10.5 billion), computers (30%), consumer electronics (22.5%), and military systems (10%). The motivating power of the industry's growth is in integrated circuitry: without technological growth in integrated circuitry, there would be little growth elsewhere. Integrated circuits are produced principally in the U.S., Britain, France, West Germany, and Japan.

The industry's firms in the U.S. are comprised of merchant firms that produce advanced integrated circuits and customized integrated circuits, and IBM and ATT which produce semiconductors only for their own consumption. The concentration of U.S. industry has not changed substantially: twenty firms have accounted for about 80% of sales in the last couple of decades (there has been a large turnover in the twenty). In Europe and Japan, the great share of semiconductor production is by mutliproduct firms similar to General Electric.

In Japan, six firms accounted for 79% of sales in 1979, and in Europe, the industrial concentration appears similar. Both Japanese and European firms have acquired part ownership of U.S. firms to facilitate market entry and technology transfer. Most of the technology growth in the industry has occurred in integrated circuitry and has had major impacts upon equipment in the four sales markets.

Major product innovations have been and continue to be the increasing density of the circuits (VLSI), the metal oxide semiconductors having favorable electrical properties, and increasingly efficient production techniques.

Moore's Law, valid since the mid 1960's, says that integrated circuit function density doubles every year with an associated decrease in cost of about 30%. For each chip density there is a similar "learning curve" showing the rapid rate at which lowest practicable unit cost is achieved. Given Moore's Law and the learning curves, it may be possible for a set of colluding firms to practice predatory pricing to exclude other firms once they have gained market dominance.

The United States' share of world shipments of integrated circuits held nearly constant in all markets in the period 1978 to 1981. A world production of integrated circuits was over $14 billion, a doubling since 1978. In this latter period, the Japanese share of market had somewhat declined from 18% to 15%.

A major threat has been posed by Japan's capture of 40% of the 16K random access memory (RAM) market, early introduction of the 64K RAM, and strong positions established for the 256K RAM in the metal oxide semiconductor markets. While European countries appear to recognize the importance of the semiconductor technology with governmental support, their industries are not yet a threat except in the specialized complementary metal oxide market.

The competitive threat in the current period is from Japan. The threat posed is mainly to U.S. merchant firms that sell on the open market and have been major contributors to technology growth. Some analysts contend that the major Japanese firms have rationalized their industry by allocating home markets in electronic devices and inhibiting both local and foreign new entry. It is claimed that these firms, using venture capital from these large scale market sales, and using recent substantial government augmenting research funds and expertise, have made it possible to target individual U.S. and world markets.

A major concern is that cooperating Japanese firms would dominate many U.S. electronic markets. They will then be able to practice a pricing policy that will limit U.S. merchant firms in the world markets just as U.S. industry appears to be limited in Japan. Large scale U.S. firms have made major contributions to the semiconductor market, but technology growth would have been much slower without the contribution of the open market firms. Thus the slowing of advances on the part of the smaller merchant firms as a result of foreign competition is highly significant.

Nonetheless, the U.S. merchant firms are not stagnating and appear determined not to allow a repeat of the 16K RAM market loss. An indication of this is seen in recent expenditures on semiconductor plant and equipment. The ten largest Japanese firms have spent $500 million in 1980 and $775 million in 1981 (about 18% of sales). The ten largest U.S. merchant firms have spent correspondingly, $910 million in 1979 and 1.2 billion in 1980.

FIBER OPTICS

Fiber optic technology has advanced rapidly since the late 1960s and now offers an ever increasing number of applications. Fiber optics have several advantages over conventional wire: they are capable of carrying much more data than wire of comparable size, they are light weight, non-conductive, neither create nor are affected by electromagnetic fields, and cannot be tapped without the risk of immediate detection. Some of the applications of fiber optics include high-density telephone transmission, computer and data transmission, office automation systems, and home video systems (cable television, videophone, and closed-circuit television).

FIBER OPTICS SYSTEMS

In a fiber optics system, pulses of light are transmitted through hair-thin optical glass fibers. There are three components of the system: light source, transmission medium, and detectors. The light source is usually a solid state laser (typically made of aluminum-gallium-arsenide) or a high-radiance light-emitting diode. Detectors are either silicon pin diodes or avalanche photodiodes. The transmission medium is generally glass but plastic-core cables have been developed for short-distance applications. The costs of fiber optics systems will decrease as these components become standardized. For example, in 1980, three U.S. companies developed standardized components for a fiber optics system suitable for short-distance, medium-speed applications. The package of components cuts the cost of relatively low-performance fiber optics to that of conventional conductors.

COMPETITION

The Japanese have been cited with a lead in light source technology and application and are competitive with the United States in the other component technologies. In Japan, MITI has targeted optoelectronics for rapid development. The Engineering Research Association in Optoelectronics Applied Systems is the core body for managing government-subsidized projects in fiber optic and other optoelectronic R&D projects. These include an $80 million optical instrumentation and control system project funded by MITI.

The falling prices of fibers and other components will permit more extensive application of this new technology in the coming years. Shipments of fiber optics systems and equipment exceeded $60 million in 1979. Increased economies of scale made possible by improvements in technology and production methods, and the higher degree of standardization being applied suggest shipments of fiber optic systems and equipment should exceed $500 million by 1986.

BIOTECHNOLOGY

The global research, industrial, economic, social and political interest in biotechnology has expanded exponentially since the mid-1970s. With the possible exception of the United States, most industrial nations have developed industrial policies or national plans that explicitly encourage investment and research in biotechnology. Major areas for application of biotechnologies identified in national reports include: pharmaceuticals/health, chemicals, energy, food processing, and agriculture.

In addition to national governments' interest in biotechnology, industy's emphasis in the future on conserving energy, on improving process efficiency, on reducing industrial hazards, and, where applicable, on moving to production of higher value added products will favor increased use of biotechnologies.

Use of fermentation and other key biotechnology process tools (enzymes, plant and animal cell cultures, recombinant DNA) will become industrial technologies of choice for the production of commercial products in the long-term. With the exception of fermentation technologies, the United States probably has the technological leadership in such biotechnological areas as recombinant DNA and cell culture technologies. These technologies, however, will only serve as tools in future commercial industrial processes. Thus, biotechnological process engineering leadership will be the critical determinant for the long-range competitiveness of those industries dependent on this technology. There are gaps not only in our technological leadership in this area but also in the manpower available to meet future industrial development needs.

Few of the factors that have affected the international competitive position of the United States in other high technology industries have had an impact on the budding biotechnology industry. Since no one is yet producing commercial products, such factors as comparative production costs and foreign pricing practices are not an issue. Capital availability does not seem to be a constraint. Large amounts of venture capital have been supplied to many small biotechnology firms in the United States to support research and product development and testing, even though most of these firms have yet to realize any sales revenue. However, capital requirements are expected to increase rapidly as firms progress to product development and commercialization, a factor favoring the major drug firms involved in the industry.

Other industrialized nations are willing to invest in filling the technological leadership voids in biotechnology. The initial cost of biotechnology research operations are not great and firms in many countries have become involved.

Japan has leading edge and extensive industrial experience in fermentation technology. MITI's vision of the 1980s report declared a strategy to deemphasize energy intensive industries and emphasive high technologies, such as biotechnology. Japan has taken a number of steps to implement their long-range government-industry strategy in biotechnology including: (1) establishing a chemical industry consortium in biotechnology, (2) formimg a fourteen-company biotechnology research organization, and (3) ensuring Japanese firms' active interest and investment in and establishment of cooperative technology transfer agreements with U.S. biotechnology firms.

There is already considerable interest in the industrial potential for biotechnology in Europe. West German industrial firms began to make substantial investments in this area in the early 1970s and West Germany is presently the technological leader within the European industrial community. Competition will increase for West Germany in biotechnology, however, as traditional European industries suffer economic difficulties over the next decade and transitions are made to high value added industrial products. European firms have been slower to invest in U.S. biotechnology companies. However, Elf Acquitaine has recently invested in Engenics, a biotechnology process engineering R&D firm.

PHARMACEUTICAL INDUSTRY

The pharmaceutical industry is one of the most successful high technology sectors of the world economy. The demand for pharmaceuticals is large and growing. The flow of new products has been sustained at a high level for 40 years, and the individual companies are generally financially healthy.

American firms dominated world pharmaceutical markets between 1940 and 1960, accounting for the vast majority of research efforts and new products, produced over half of world pharmaceutical, and controlled one-third of international trade in medicinals.

Since the early 1960s, the U.S. share of world pharmaceutical research, innovation, production, sales, and exports have declined. Additionally, the number of U.S. firms that are active participants in the various ethical drug markets have been constant or declined relative to their foreign counterparts since 1960.

DECLINE IN INNOVATION

Patented drugs represent the driving force of the modern pharmaceutical industry and are responsible for the spectacular growth in sales since 1940. Modern pharmaceutical firms depend on a small handful of successful innovations for the bulk of their positive cash flow. Competitive advantage in sales of patented drugs, by far the most lucrative segment of the industry, depends on the ability of the firm to produce a slow but steady stream of commercially successful new products through industrial innovation.

The process of pharmaceutical innovation is characterized by substantial risks. This is, in part, a result of the lengthy time frame--sometimes approaching fifteen years--from initiation of basic research to the commercial launching of a new product. While U.S.-owned firms' expenditures for pharmaceutical research at home and abroad are large and growing, they have not increased to the extent where they can match the exceptional expansion of foreign-owned research efforts. The share of world pharmaceutical research located in the United States remains the largest, but has fallen from about two-thirds in the early 1960s to above one-third today. Research expenditures have grown faster throughout the period in Japan, West Germany, and the United Kingdom.

Levels of innovation in the industry have been, at best, stable for the last two decades but have sharply dropped from the levels of the 1950s. The average cost per innovation has risen drastically in the last 20 years. A frequently cited figure is $54 million (1976 dollars) per new chemical entity (NCE). The fundamental reason for the dramatic increase in innovation costs lies in the substantially greater number of clinical trials and toxicology testing performed in the process of bringing a new compound to market. The upward trend in costs is an international phenomenon that has led all industrial nations to comparable extensive pretesting and selectivity in pursuit of new drugs. The inevitable consequence has been a worldwide decline in introduction rates. Yet, foreign levels of innovation have declined less severely since the 1950s than U.S. levels

Two basic changes in the structure of the world pharmaceutical industry have evolved during the past two decades: greater concentration of innovation among larger firms and increased internationalization of the industry. The higher costs per innovation for smaller firms render small-scale research operations relatively less productive per dollar spent and, hence, less profitable. A consequence of this development has been the declining significance of smaller firms in the pharmaceutical innovation process.

Between 1965 and 1975, U.S.-located production grew 5 percent annually compared to 15 percent rate abroad. Growth rates of overseas production for U.S.-owned firms exceeded those of domestic producton, with foreign production accounting for 40 percent of the U.S. multinational total in 1978.

Pharmaceutical products have traditionally provided a surplus for the U.S. trade balance. Yet, this surplus in absolute terms is not significantly greater than those of Switzerland, West Germany, or the United Kingdom, who export a larger percentage of their production than the United States despite the substantially larger level of U.S. production. This lower level of exports as a proportion of domestic production provides the United States with a comparable share of world pharmaceutical exports, a share which has markedly deteriorated since 1950. In part, the low proportion of pharmaceutical preparations production devoted to exports is associated with the relatively more extentive multi-national scope of U.S.-owned firms, which has resulted in significant exports of medicinal chemicals. Equally important is the traditional relative unimportance of exports to U.S. producers, as may be seen by a comparison of total U.S. exports to GNP. From this perspective, the U.S. pharmaceutical industry is typical of other sectors of the American economy.

BARRIERS TO U.S. EXPORTS

While tariffs are of little consequence to U.S. pharmaceutical exports, non-tariff barriers most definitely are. The French have a visa system which, in practice, favors French firms rather than the affiliates of foreign companies. The United Kingdom, through its price regulation, gives firms an incentive to perform R&D there instead of in the United States. But in general, the most important barrier to U.S. exports is FDA regulations preventing the export of any new drug until it has been approved for sale in the United States. This applies even if the product has been formally approved for marketing in the importing nation. With the delays that occur in obtaining FDA approval, U.S. firms have more incentive to manufacture new drugs abroad.

INDUSTRIAL ROBOTICS

Industrial robot manufacturing has experienced rapid growth during the past two years, and industry observers project average annual growth rates of 35 percent or more during the coming decade. The first industrial robot was developed in the United States about 1960, and the United States continues to be the world leader in research and design. But in the past decade Japan has far surpassed the United States in both the production and use of robots.

The U.S. robotics industry has been dominated by two firms -- Unimation and Cincinnati Milacron. Together they accounted for about 70 percent of U.S. robot sales in 1980. With the entrance of several new firms into the industry, however, this share is expected to drop to 50 percent in 1982. The past two years have seen a tremendous upsurge in interest in robots. There has been a dramatic increase in the corporate membership of the Robot Institute of America, the industry trade association, from 45 in 1979 to 172 in 1981. Several U.S. firms (General Electric, Westinghouse, Automatix, and others) have concluded licensing agreements to market robots built by foreign companies--West German, Italian, Swedish, and Japanese. In the case of at least one of these firms, General Electric, licensing is seen as an entrance to the market while work continues on the development of their own robots.

The belated but rapidly growing interest in robots in the United States is due in part to the increasing economic justification for purchasing robots resulting from declining robot prices and rising wage levels in recent years. Reports by industry analysts suggest that existing and potential robot manufacturers are only awaiting assured markets before investing in the additional capacity needed to sustain the surge that is under way.

Capital availability does not seem to be a constraint. More than $30 million in venture capital was channeled into U.S. robot companies during the past two years. After the surge of new producers in the next few years, analysts expect a "shake-out" with the number of bankruptcies and acquisitions increasing. Survival will depend on producers being financially strong enough to develop programmable robots or to carve out specialized niches. Prices for sophisticated robots will also go down as the result of increased competition and economies of scale. By 1990, according to one study, almost half of factory assembly operations will incorporate robot technology, compared with only 5 percent today.

FOREIGN COMPETITORS

The first Japanese robots were produced in the late 1960's under license from American firms. Many of the Japanese producers initially designed and built robots for their own use and only later decided to market them. Domestic demand has continued to absorb most of their output, with exports currently accounting for only about 3 percent. A movement toward increased exports is now under way and the Japanese Industrial Robot Association projects exports of about 15-20 percent of total output during the second half of the 1980s.

Japanese manufacturers have developed robots for a broad spectrum of applications. The development of their robot industry was aided by a much more receptive climate in Japan than in the United States and by direct government efforts to encourage robot use and support robotics research. Factors most frequently mentioned are:

- The management of many Japanese companies turned to robotics during the 1970s as a means of achieving higher quality (greater precision, lower defect rates) and improving productivity.

- Labor in Japan has been receptive to robots because of the permanent employment policy, company efforts to retrain those displaced, and the fact that workers share in the larger profits resulting from higher productivity.

- The major government actions have been:

  a. direct low-interest loans through the Small Business Finance Corporation to small and medium-scale manufacturers for robot purchases;

  b. extra depreciation allowances on robots--an additional 12.5 percent each year for three years (a firm can depreciate 52.5 percent of the purchase price in the first year);

  c. encouraging the formation in 1980 of the Japan Robot Leasing Company (JAROL), which is jointly owned by 24 robot manufacturers and 10 insurance companies (since 60 percent of operating expenses are financed by low cost loans from the Japan Development Bank, JAROL can provide very attractive leasing terms); and

  d. a major new effort to support R&D in robots--$150 million to be allocated by MITI over seven years, beginning within the next year, to push the development of intelligent robots.

West Germany has several important robot manufacturers, and the government provides considerable support for R&D and for the training of engineering and technical personnel. Their production has been primarily for internal consumption and for other European countries. Few of the West German robots have reached the United States.

Italy was one of the earlier starters in robotics, but their production volume is low. The Italian firms Olivetti and DEA have recently signed licensing agreements with U.S. firms to market their robots in the United States.

The major French robot producer is Renault, which also has a licensing agreement with a U.S. firm. The French government is firmly behind automation and robotics programs, and it is estimated that the government is putting about $25 million per year into funding related research programs.

The United Kingdom has gotten off to a slow start in robotics, hampered by union problems, but has set up a Scientific Research Council to focus on this industry.

The U.S.S.R. has an entensive robotics research program, but is at least a decade behind the United States in robotics technology. It is receiving about 100 robots a month from a factory in Bulgaria. Poland has a limited research effort and very little production.

THE OUTLOOK FOR THE 1980s

The wider use of robots encouraged by government policies has given the Japanese the lead not only in the quantity produced but also in the range of applications. At present about 55 percent of all robots in the United States are used in the automotive industry. In Japan, about one-third of all robot shipments have been to the automotive industries, and one-quarter to the electric appliance industry. In the United States about 49 percent of all robots are used for welding and painting, and 21 percent for machine tool loading and assembly operations. In Japan the corresponding shares are 16 percent and 77 percent. The latter two applications are expected to be the major U.S. growth markets in coming years. That the Japanese already have product-development experience in these areas should give them an advantage in the U.S. market.

ADDITIONAL REFERENCES: Sallot, Bernard M. "The Status of Robots in the United States and in Other Countries," paper presented to the Thirteenth Annual Department of Defense Manufacturing Technology Conference, November 30 - December 3, 1981.

MACHINE TOOLS

The machine tool industry in the United States is quite small, yet it is important to U.S. economic and military strength Virtually every major manufactured product is produced on machine tools or on machines built by machine tools. Modern and efficient machine tools are needed to meet increased military production demands in times of national emergencies. Many major American industries, such as the automotive and other transportation industries, are closely dependent on machine tools for the maintenance of their competitiveness in domestic and world markets. Increased foreign penetration of the U.S. market, coupled with a decline in world market share of machine tools, are sources of concern for the future of the U.S. industry, in spite of increasing orders and shipments.

LOSS OF MARKET SHARE

The U.S. machine tool industry employs approximately 100,000 persons and its output is valued at around $4 billion. Two-thirds of the companies are small, employing under 20 persons. The U.S. share of worldwide production of machine tools was around 35 percent in 1967 but dropped precipitously to 17 percent in 1971 where it has since leveled out. Western Europe has maintained a steady share between 15 and 20 percent. Japan's share, on the other hand, has shown a rapid increase from 5 percent to 13 percent. The U.S. industry had a negative trade balance for the first time in 1978--by 1980, the deficit had grown to over $500 million. Imports now account for 24 percent of U.S. consumption. U.S. exports of machine tools in 1980, valued at $748 million, trailed behind West Germany, Japan, Italy, and Switzerland.

The machine tool industry suffers from highly cyclical demands, causing periods of "feast or famine." This was especially evident during the period 1967-1971, when there was a drop in U.S. machine tool consumption of around 48 percent. The industry did not offset this slow period by increasing its exports into an expanding world market. Instead, many companies "retrenched," cutting back on personnel, capital expenditures, and research and development, and discarding marginal product lines. However, this resulted in long lead times, large order backlogs, and therefore, increased vulnerability to foreign competition.

NEW TECHNOLOGIES

Many American tool builders have also failed to keep pace with the productivity, quality, and cost savings of their international competitors. While many of the new advances in product design and manufacturing techniques are developed in the United States, our industry has been less willing to take advantage of them than our competitors. The Japanese study mission of the National Machine Tool Builder's Association toured 13 Japanese factories and found: "Nowhere in the 13 factories toured by our study group did we see any unique manufacturing technology. In general, Japanese machine tool builders use the same types of machinery to build their products as in America. However, the equipment and technology are very intelligently applied and many builders are investing heavily in the latest technology to improve productivity further."

Computer numerically controlled machines (CNC) and flexible manufacturing systems (FMS) will play a major role in the machine tool industry in the coming decade. An FMS consists of a group of CNC tools connected by a mainframe computer. These systems are used to manufacture a family of diverse parts. The emphasis among U.S. companies is still on simple machines, however, rather than systems. The Japanese, on the other hand, have targeted flexible manufacturing systems as a specialty to mass market and their experience will give them an advantage as demand increases in world markets.

ADDITIONAL REFERENCES: Bureau of Industrial Economics, 1982 U.S. Industrial Outlook, U.S. Department of Commerce, 1982.

The Japanese Study Mission of the National Machine Tool Builder's Association, "Meeting the Japanese Challenge," National Machine Tool Builder's Association, McLean, Virginia, 1981.

APPENDIX D

THE INNOVATIVE PROCESS

This appendix provides some background on definitions and key considerations concerning innovation. Further background information can be found in the selected sources discussing the innovative process which are listed at the end of the appendix.

Definitions of Research and Development

The National Science Foundation (NSF), in its surveys of industrial technology activities, separates the innovative activities of firms into three categories: Basic Research, Applied Research, and Development. Basic research is generally considered to be long-term in nature, not focused on specific, identifiable short-term objectives. However, basic industrial research is ultimately aimed a producing or improving upon a marketable product. Applied research is more specific and, presumably, short-term. Since basic research and applied research have similar ultimate objectives it is frequently difficult to distinguish between the two in industrial settings.

The NSF definitions of research and development and the three categories of R&D activity are:

"Research and development - Basic and applied research in the sciences and engineering and the design and development of prototypes and processes. This definition excludes quality control, routine product testing, market research, sales promotion, sales service, research in the social sciences or psychology, and other nontechnological activities or technical services."

"Basic research - Original investigations for the advancement of scientific knowledge not having specific commercial objectives, although such investigations may be in fields of present or potential interest to the individual company."

"Applied research - Investigations directed to the discovery of new scientific knowledge having specific commercial objectives with respect to products or processes. This definition differs from that of basic research chiefly in terms of the objectives of the individual company."

"Development - Technical activities of a non-routine nature concerned with translating research findings or other scientific knowledge into products or processes. Does not include routine technical services to customers or other activities excluded from the definition of research and development given above."

Innovation

Industrial innovation is generally defined as the initial commercial application of a new product or process. Innovation encompasses changes in either product features or production processes to reduce costs. For our purposes, innovative behavior can be considered to include both innovation by a firm itself and the adoption and improvement of innovations made by others. The activities leading to innovation involve a long-term process incorporating the various stages of research, development, capital investment, and commercialization.

Factors In the Innovative Process

Innovation by a firm is influenced by both internal elements and conditions outside the firm that provide it with opportunities or constrain its behavior. The government, rather than individual firms, has principal influence over the external elements.

Major External Factors -- Important external factors have been identified to include the following:

- o The technological base: The state of overall knowledge in the economy, the flow of scientific and technical manpower to industry and the amount of on-going basic research in government and academic institutions.

- o Overall economic conditions: Aggregate demand and investment rates, which tend to promote or restrict innovation, and effect the rate of adjustment--particularly of labor--to technological change.

- o Price stability: Rates of inflation and financial market volatility which can particularly affect innovation. (Under high inflation firms show preference for short-term, low-risk investments rather than radical innovations with risky and long-term return characteristics,)

- o Industry composition: Industry structure in terms of concentration and size of firms which influence whether firms are large enough or secure enough to carryout innovative changes with long-term returns.

- o Government policies: The government policies affecting industries, whether targeted to industries or toward other national objectives. (Government regulations, specifically, can cause a concentration on short-term problem-solving.)

- o R&D incentives: The degree to which the external economies, riskiness and indivisibilities in R&D are accounted for. (Studies of the social rate of return to R&D programs indicate that the marginal social rate has been very high versus the private rate -- thus suggesting potential underinvestment in R&D.)

Major Internal Factors -- Firm resources and actions at all levels can have a significant influence on innovation. Important specific elements include:

- o Corporate goals: Specific objectives concerning the rate of return, market share, profit growth, etc., which in everyday operation guide decisions about entering into new products or processes.

- Firm organization: Degree of vertical integration and type and amount of capitalization. (The proportion of debt relative to equity, cash flow, and size of working capital all affect the ability to develop new products, new plant and equipment, and compete in markets.)

- The state of internal coordination and communication: Degree to which all levels of the corporation focus on the development and practical application of technology, from project selection, technical discoveries, through marketing success.

- Managerial quality: Level of understanding of technological base of the industry, and technical sophistication of management. (Managers selected primarily for business and general management skills may lack appreciation for the necessity of long-range research and development programs. For instance, U.S. practices of high-level executives moving between industries with insufficient time to learn about the industry's technical base, contrasts with Japan's relatively long executive ties with the same firm and the technical expertise acquired as a result.)

- Company reward systems: Rewards and bonuses based on short-term versus long-term results. (Long-term investments in new and relatively risky technologies have little immediate payoff and will not be encouraged if rewards emphasize short-term results.)

Innovation and Risk

One of the obvious characteristics of the innovative process is its riskiness. This uncertainty can be broken down into three primary categories: (1) the chance that a project will not be technically completed, (2) the chance that a product, if technically completed, will not be commercialized, and (3) the chance that a project, if commercialized, will not be economically successful.

Empirical investigations of the innovative process provide evidence of the risks associated with innovative activities. An early study by Booz, Allen and Hamilton concluded that 7 out of 8 hours devoted by scientists and engineers in major firms to technical product development are spent on unsuccessful projects, and that 5 out of every 10 products that emerge from R&D fail in product and market tests, and only 2 become commercial successes. A detailed study of the R&D portfolio of several chemical and drug firms indicated that, on the average, about 43 percent of the projects that were begun were not technically completed, about 45 percent of those that were technically completed were not commercialized and about 62 percent of those commercialized were not economic successes -- that works out to a success rate of approximately 12 percent of the R&D projects initiated. Though the probability of success varies among industries and among firms within an industry, the high level of risk associated with innovation can easily lead to underinvestment in these activities.

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